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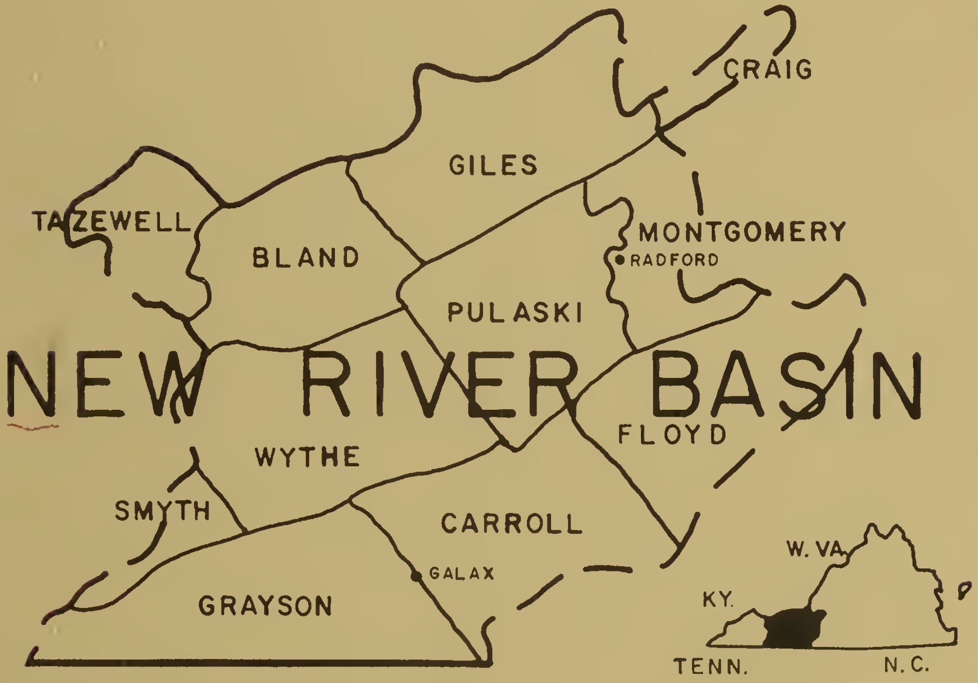

NEW RIVER BASIN

COMPREHENSIVE WATER RESOURCES PLAN

VOLUME V - ENGINEERING DEVELOPMENT ALTERNATIVES

PLANNING BULLETIN 205

1967

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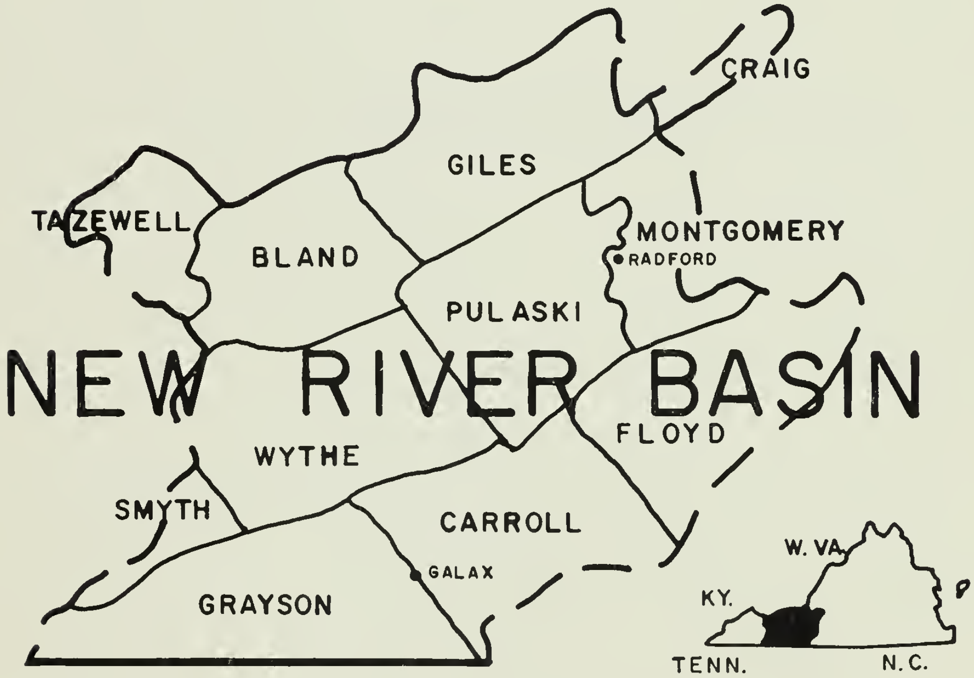

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NEW RIVER BASIN COMPREHENSIVE WATER RESOURCES PLAN

Volume V - Engineering Development Alternatives
Planning Bulletin 205

Commonwealth of Virginia

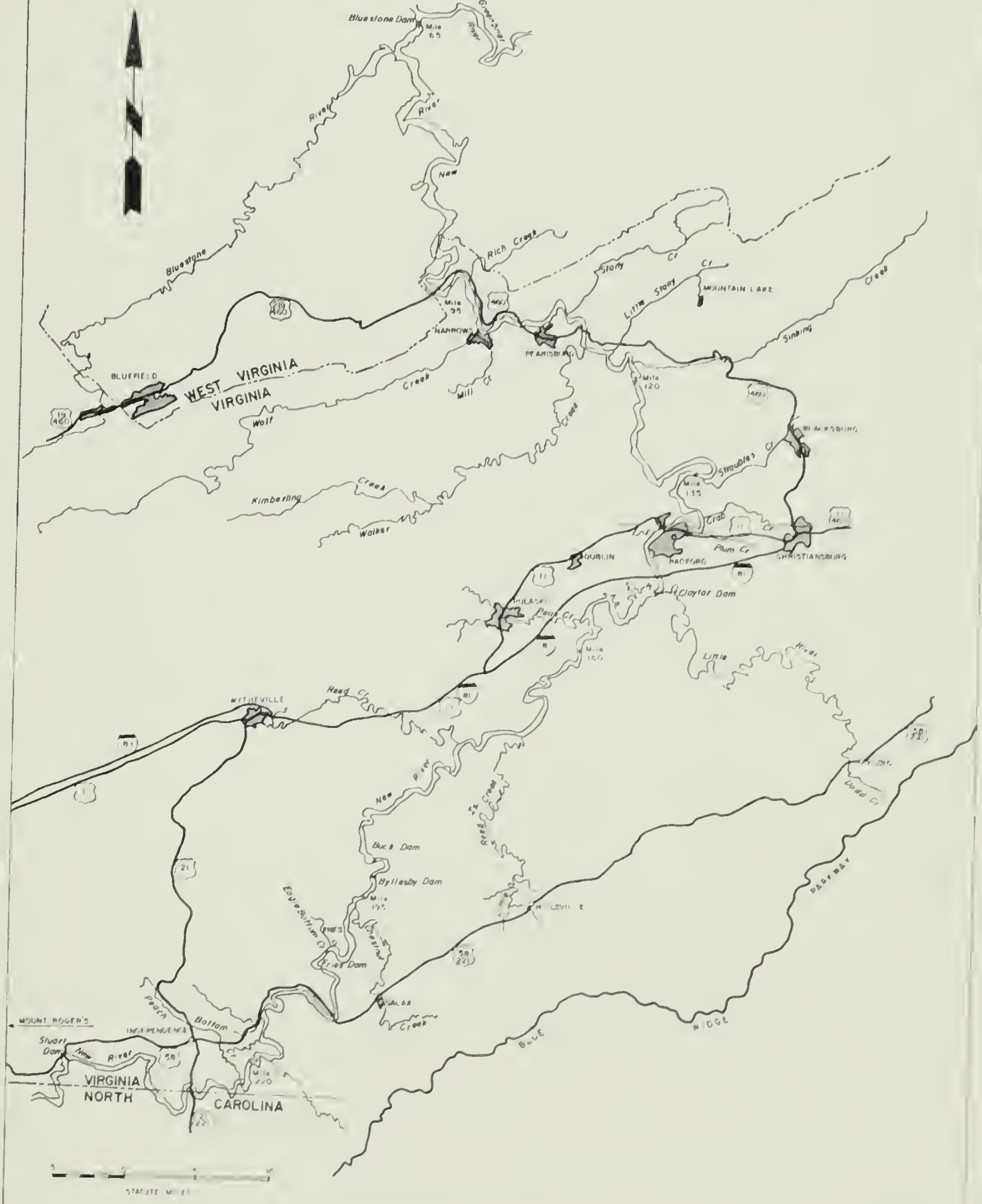
Department of Conservation and Economic Development

Division of Water Resources

Richmond, Virginia

September - 1967

NEW RIVER



DIVISION OF WATER RESOURCES	SC. BAR	DATE 8-3-67		SHT. 1	OF 1
NEW RIVER	DE.	DR. M.N.F.	APP.	REV	NO. 101

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ACKNOWLEDGMENTS

In Volume I, Planning Bulletin 201, of the New River Basin Comprehensive Water Resources Plan in Virginia, December 1966, the Division of Water Resources of the Virginia Department of Conservation and Economic Development gratefully acknowledged the contributions of a number of Federal, State, and local governmental agencies and corporate or private organizations. Twelve of the contributing departments and divisions of the Virginia State Government were listed along with the names of the eleven counties and two cities of the New River Basin in Virginia whose officials and citizens have cooperated in the survey. The continuing interest of all of these in the survey and the subsequent bulletins is appreciated.

FOREWORD

The Comprehensive New River Basin Water Resources Plan is contained in six volumes. These volumes are as follow:

Volume I - Introduction
Volume II - Economic Base Study
Volume III - Hydrologic Analysis
Volume IV - Water Resource Requirement
Volume V - Engineering Development Alternatives
Volume VI - Implementation of Development Alternatives.

Volume V contains a presentation of development alternatives to meet the water resource requirements outlined in Volume IV The Volume also contains an analysis of the potential value of the water resource in the Basin under a scheme of ultimate development.

The following abstracts of chapters are included for the benefit of those reading this Volume who do not wish to examine the technical detail contained in the Volume. The abstracts will also serve as a guide for those who may wish to examine particular portions of the publication.

Chapter I includes statistical data relating to possible reservoir sites in the Basin. The material includes information prepared by Federal agencies as well as data compiled by the Division of Water Resources.

Chapter II outlines the alternatives for meeting water supply and pollution assimilation needs. A detailed discussion of future waste problems in the upper and lower Basin is presented. Irrigation requirements and the cost of meeting these requirements are included in the Chapter.

Chapter III contains an analysis of several potential hydroelectric power projects which may be used to meet power demands in the Virginia New River Basin and to supplement other power sources in meeting demands in national power supply areas 9 and 10.

Chapter IV is a discussion of flood control requirements in the Virginia New River Basin. Values of flood damages in the entire Ohio River Basin, of which the New River is a portion, are given in the Chapter and particular attention is given to damages in the Bluefield, Virginia, area.

Chapter V is a study of the potential value of the water resources in the Basin under various levels of development. An analysis of value associated with two management plans for the proposed Appalachian Power Company Blue Ridge Project is included in the Chapter.

Chapter VI shows a possible scheme of reservoir regulation under several levels of development. A study of the Chapter will permit the reader to ascertain the effect of possible future development on flows in the New River and certain selected tributaries.

Volume V presents certain alternatives to meet foreseeable future needs and ultimate development possibilities. An overall plan for the Basin will be selected from these alternatives. The recommended plan will be contained in Volume VI of the New River Study.

CHAPTER I

RESERVOIR SITES IN THE NEW RIVER BASIN

Any development plan for the use of water in the New River Basin will include an inventory of the potential water resource with regard to its location, amount, and developable limits. The tables and plates following this text in Chapter I are presented for the purpose of showing the location, amount of water, and storage available at those sites studied by the Soil Conservation Service, Corps of Engineers, and the Virginia Division of Water Resources.

Table 1 contains those reservoir sites examined by the Corps of Engineers and the Division of Water Resources having a watershed area greater than 10 square miles. Those sites assigned numbers under 100 are Corps of Engineers' sites and are under further investigation by the Corps. Corps Site 71, New River near Independence, is the same as the Virginia Division of Water Resources' Site 180, or Appalachian Power Company's "Blue Ridge Project". Those sites in Table 1 having numbers 100 or greater are potential sites for development selected by Virginia Water Resources personnel.

It should be noted that those sites presented in Table 1 by the Division of Water Resources have not been extensively investigated with respect to geologic feasibility and location. They were developed from topographic and hydrologic studies with limited field inspection and from a knowledge of the possible water needs in specific areas. However, the data for Virginia Site 180 (proposed Blue Ridge Project) was adapted from information supplied by Appalachian Power Company, which has applied for a Federal Power Commission license to construct this project.

Plate 1 shows the location of those sites listed in Table 1.

Table 2 was prepared by the Economic Research Service, Forest Service and Soil Conservation Service of the United States Department of Agriculture. This Table was taken from an Interim Report on the Upper New River Sub-Basin of the Kanawha Basin Comprehensive Survey. Table 2 lists those sites and data thereon for upstream watersheds of the Upper New River Sub-Basin which have outstanding potential for any or all purposes.

Plate 2 shows the location of those sites listed in Table 2.

Plates 3 through 21 illustrate the stage-storage capacity and stage-area relationships of those sites listed in Table 1.

RESERVOIR SITES

NEW RIVER BASIN IN VIRGINIA

DRAINAGE AREA GREATER THAN 10 SQUARE MILES

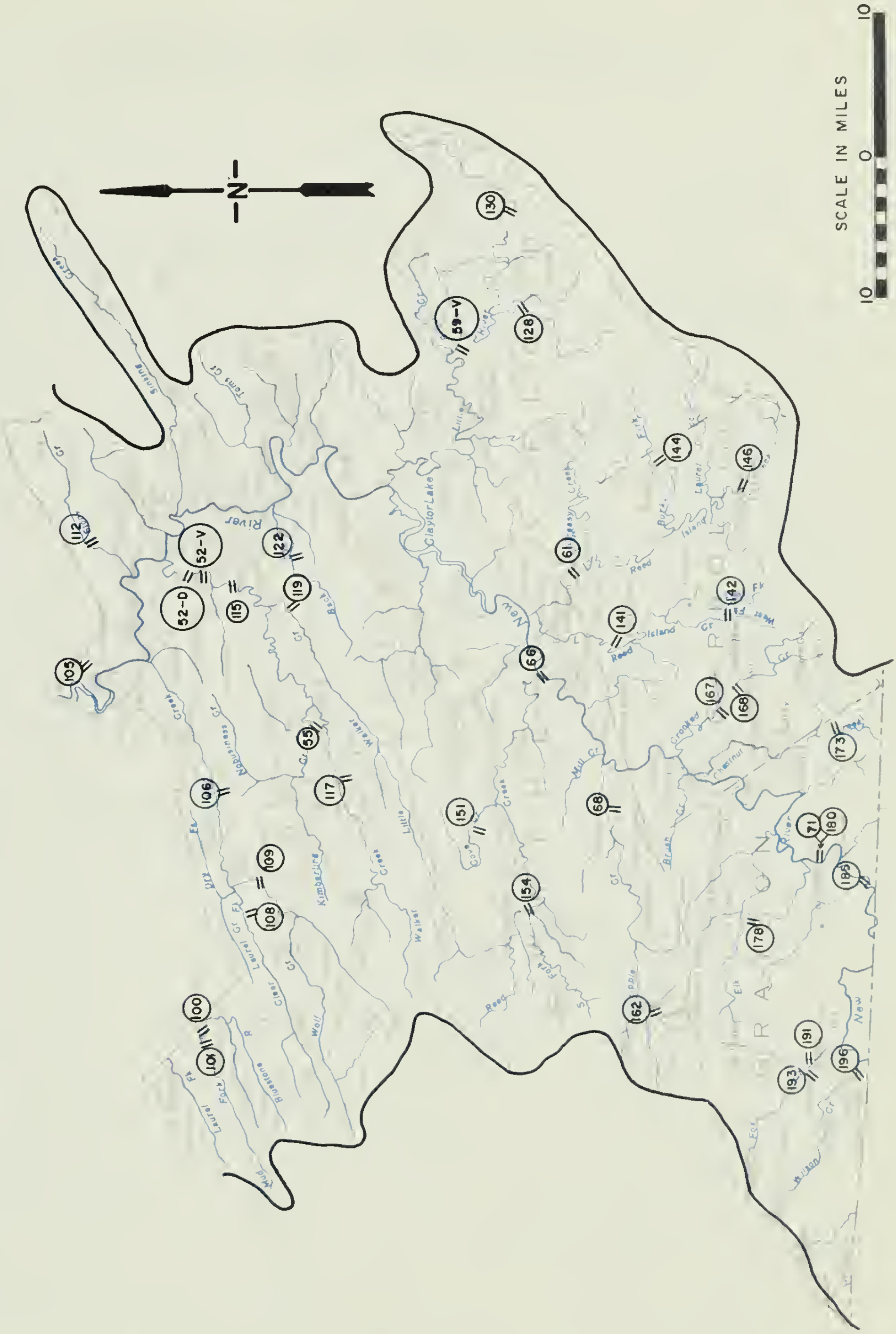

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PLATE NO. 1

TABLE 1

RESERVOIR SITES IN NEW RIVER BASIN
(Drainage Area Greater Than 10 Square Miles)

1	2	3	4	5	6	7	8	9
Site No.	Name and Location	Drainage Area In Sq. Mi.	Average Annual Runoff (In.)	Maximum Storage Capacity 1000 Ac.-Ft.	Elevation Above M.S.L. at Maximum Capacity	Area In Acres	Ratio of Max. Storage** / Average Runoff**	Average Annual Runoff In MGD
52-0	Walker Creek near Pearisburg, Va. Lat. 37°18'27"; Long. 80°41'40" (Pearisburg Quad.)	308	14.0	503	1,880	6,600	2.187	205
52-V	Walker Creek near Pearlsburg, Va. Lat. 37°17'20"; Long. 80°42'15" (Pearlsburg Quad.)	303	14.0	546	1,900	7,150	2.413	202
55	Kimberling Creek near Mechanicsburg, Va. Lat. 37°09'56"; Long. 80°53'50" (Pulaski Quad.)	90.0	15.0	184	2,160	4,250	2.556	64
59-V	Little River near Riner, Va. Lat. 37°00'40"; Long. 80°24'00" (Blacksburg Quad.)	198	17.0	290	2,240	5,000	1.615	160
61	Big Reed Island Creek near Allisonia, Va. Lat. 36°54'00"; Long. 80°42'10" (Macks Mountain Quad.)	259	19.5	626	2,270	7,150	2.324	240
66	Reed Creek near Lone Ash, Va. Lat. 36°55'40"; Long. 80°50'00" (Max Meadows Quad.)	258	14.2	322	2,060	6,800	1.648	174
68	Cripple Creek near Ivanhoe, Va. Lat. 36°51'00"; Long. 81°00'10" (Speedwell Quad.)	136	15.0	123	2,200	2,550	1.131	97
71	New River near Independence, Va. Lat. 36°38'27"; Long. 81°03'50" (Independence Quad.)	1,000	22.0	1,350	2,500	16,000	1.151	1,047
100	Brush Fork near Falls Mills, Va. Lat. 37°16'40"; Long. 81°17'45" (Bramwell Quad.)	10.7	16.0	33.5	2,400	845	3.669	8
101	Mud Fork near Falls Mills, Va. Lat. 37°16'20"; Long. 81°19'19" (Bramwell Quad.)	17.9	15.5	31.6	2,400	735	2.136	13
105	Rich Creek below Peterstown, W.Va. Lat. 37°23'49"; Long. 80°49'10" (Narrows Quad.)	54.0	15.0	59.0	1,700	840	1.366	39
106	Lower Wolf Creek above Boxley, Va. Lat. 37°15'43"; Long. 80°58'49" (Narrows Quad.)	198	17.7	193	2,100	1,920	1.033	167
108	Clear Fork above Rocky Gap, Va. Lat. 37°13'48"; Long. 81°08'57" (Bland Quad.)	43.0	18.0	30.9	2,240	685	0.749	37
109	Upper Wolf Creek at South Gap, Va. Lat. 37°13'08"; Long. 81°05'35" (Bland Quad.)	111	20.0	117	2,200	2,550	0.988	106
112	Stony Creek near Kerns, Va. Lat. 37°24'02"; Long. 80°39'28" (Pearisburg Quad.)	35.8	16.0	38.7	2,250	330	1.267	27
115	Lower Walker Creek near Bane, Va. Lat. 37°15'06"; Long. 80°42'29" (Pearlsburg Quad.)	276	14.0	214	1,900	3,390	1.038	184
117	Walker Creek above Mechanicsburg, Va. Lat. 37°07'52"; Long. 80°58'11" (Pulaski Quad.)	68.8	14.8	64.0	2,300	1,120	1.179	48
119	Little Walker Creek near Frenchs Chapel, Va. Lat. 37°11'23"; Long. 80°44'48" (Radford Quad.)	55.1	14.5	88.4	2,000	1,530	2.075	38
122	Back Creek above Parrott, Va. Lat. 37°11'04"; Long. 80°40'05" (Radford Quad.)	24.4	14.5	16.4	1,940	470	0.869	17

TABLE 1 (Continued)

RESERVOIR SITES IN NEW RIVER BASIN
(Drainage Area Greater Than 10 Square Miles)

1 Site No.	2 Name and Location	3 Drainage Area In Sq. Mi.	4 Average Annual Runoff (In.)	5 Maximum Storage Capacity 1000 Ac.-Ft.	6 Elevation Above M.S.L. at Maximum Capacity	7 Area In Acres	8 Ratio of Max. Storage** / Average Runoff**	9 Average Annual Runoff In MGD
128	West Fork Little River near Floyd, Va. Lat. 36°57'02"; Long. 80°21'14" (Floyd Quad.)	43.7	18.0	81.9	2,280	1,790	1.952	37
130	Upper Little River near Woods Store, Va. Lat. 36°57'55"; Long. 80°13'44" (Endicott Quad.)	46.9	18.5	42.3	2,360	1,050	0.914	41
141	Little Reed Island Creek near Sylvatus, Va. Lat. 36°51'08"; Long. 80°46'52" (Max Meadows Quad.)	62.0	19.0	67.0	2,240	1,110	1.066	56
142	Upper Little Reed Island Creek near Hillsville, Va. Lat. 36°44'11"; Long. 80°45'01" (Galax Quad.)	21.3	19.5	59.2	2,520	1,090	2.672	20
144	Burks Fork near Mt. Hebron Church, Va. Lat. 36°48'16"; Long. 80°33'19" (Macks Mountain Quad.)	27.5	19.5	18.3	2,480	542	0.640	26
146	Upper Big Reed Island Creek near Gladesboro, Va. Lat. 36°43'05"; Long. 80°35'17" (Mount Airy Quad.)	38.4	20.0	56.9	2,520	1,250	1.389	37
151	Cove Creek near Bethel, Va. Lat. 36°59'37"; Long. 81°01'40" (Speedwell Quad.)	28.7	14.5	14.5	2,180	467	0.653	20
154	Upper Reed Creek above Wytheville, Va. Lat. 36°56'42"; Long. 81°09'56" (Speedwell Quad.)	53.6	14.8	24.8	2,260	860	0.586	38
162	Blue Spring Creek below Cedar Springs, Va. Lat. 36°48'44"; Long. 81°15'36" (Cedar Springs Quad.)	13.5	15.5	10.4	2,460	335	0.932	10
167	Lower Crooked Creek near Hebron, Va. Lat. 36°44'12"; Long. 80°52'22" (Galax Quad.)	56.1	20.0	66.6	2,380	1,390	1.113	53
168	Upper Crooked Creek near Woodlawn, Va. Lat. 36°43'38"; Long. 80°51'03" (Galax Quad.)	37.0	21.0	23.1	2,380	710	0.557	37
173	Chestnut Creek near Galax, Va. Lat. 36°38'05"; Long. 80°54'20" (Galax Quad.)	31.5	23.0	28.8	2,460	990	0.745	34
178	Elk Creek near Lower Elk Creek Lat. 36°42'33"; Long. 81°09'16" (Independence Quad.)	49.3	22.0	63.3	2,600	1,920	1.094	52
180	New River near Independence, Va.- Blue Ridge Project Lat. 36°38'27"; Long. 81°03'50" (Independence Quad.)	1,000	22.0	1,750	2,520	21,200	1.491	1,047
185	Peach Bottom Creek below Independence, Va. Lat. 36°35'20"; Long. 81°05'54" (Independence Quad.)	24.9	23.0	37.1	2,460	623	1.215	27
191	Middle Fox Creek near Barton Crossroad, Va. Lat. 36°38'47"; Long. 81°19'33" (Mouth of Wilson Quad.)	20.3	24.0	22.6	2,680	455	0.870	23
193	Fox Creek near Barton Crossroad, Va. Lat. 36°38'17"; Long. 81°20'23" (Mouth of Wilson Quad.)	45.5	23.0	39.7	2,640	810	0.711	50
196	Wilson Creek near Mouth of Wilson, Va. Lat. 36°35'38"; Long. 80°21'02" (Mouth of Wilson Quad.)	32.0	23.5	34.6	2,640	648	0.863	36

* - Estimated on basis of runoff records computed from flow records of stream gaging stations in and around the New River Basin.

** - This column is the ratio of Maximum Storage Capacity (Column 5) converted to inches to the Average Annual Runoff (Column 4) in inches.

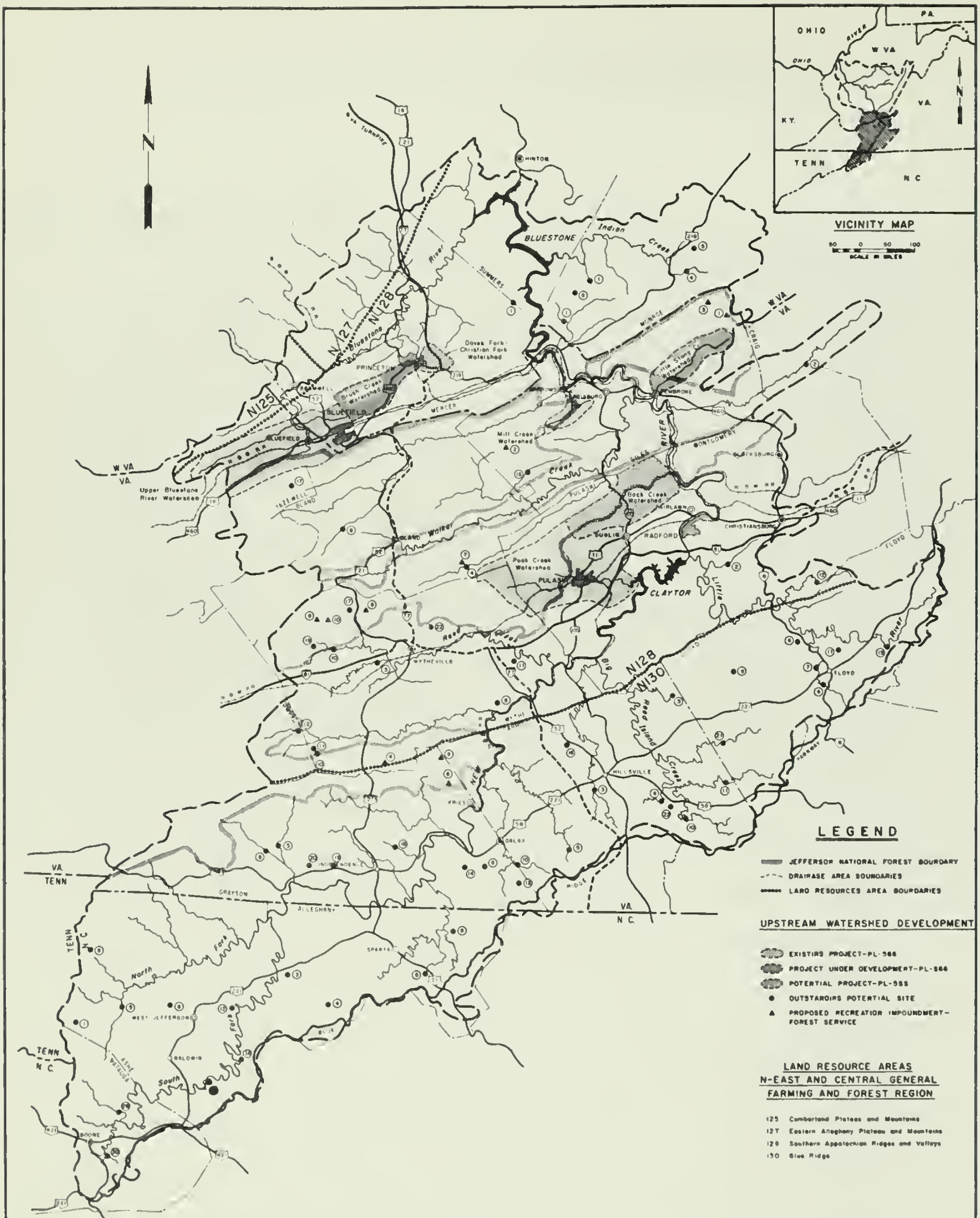


FIGURE I

UPPER NEW RIVER SUB-BASIN

BASE MAP PREPARED BY
HUNTINGTON DISTRICT CORPS OF ENGINEERS
1966

PLATE NO. 2

TABLE 2

OUTSTANDING STORAGE AND RECREATION SITES

Upper New River Subbasin, Kanawha River Basin
Courtesy of U. S. Department of Agriculture, Soil Conservation Service

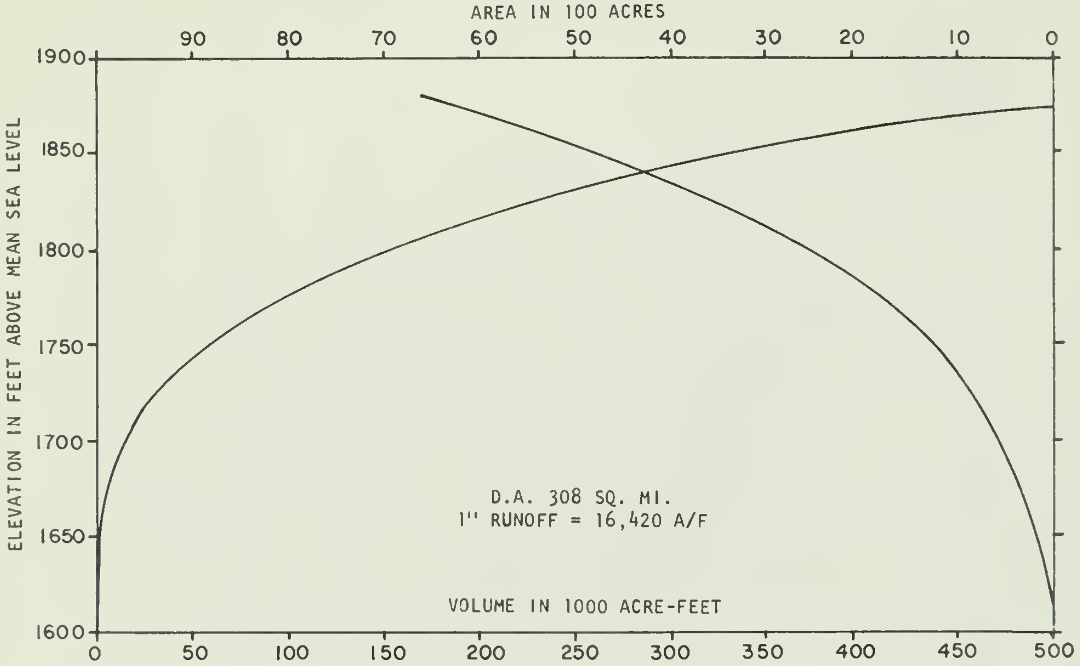
CNI Watershed Number	Site Number	Stream Name	Drainage Area (Sq. Mi.)	STORAGE Flood (Ac. Ft.)	STORAGE Beneficial (Ac. Ft.)	Surface 1/ Area (Acres)
NC-1	3	Mulberry Creek	32.31	7,930	13,800	350
	4*	Piney Fork	5.51	1,380	2,350	140
	12*	Naked Creek	12.11	2,970	5,180	270
	14*	Obid Creek	6.09	1,490	2,600	140
	16*	Pine Swamp Creek	12.35	3,030	5,270	230
	28	Meat Camp Creek	18.91	4,640	8,070	290
	30*	East Fork	5.78	1,420	2,470	170
NC-2	1*	North Fork New River	16.60	5,200	5,950	290
	5*	Three Top Creek	22.73	-	5,560	310
	6*	Laurel Fork	11.10	2,730	4,740	200
	9*	Buffalo Creek	12.49	3,060	5,330	150
NC-3	6*	Glade Creek	7.22	1,770	3,080	150
	8*	Brush Creek	37.40	9,180	15,960	690
NC-Va-6	18	Rock Creek	4.70	1,150	2,000	110
	19*	Saddle Creek	5.06	1,250	2,180	120
	20*	Bridle Creek	4.52	1,100	1.920	110
Va-7a-2	8	Hunting Creek	9.49	2,380	4,050	180
	17*	Cove Creek	12.13	3,040	5,080	220
Va-7a-3	2	Little Stony Creek	12.25	2,630	5,290	340
Va-7a-4	1*	Stony Creek	20.35	5,120	8,760	480
Va-7a-5	16	Dismal Creek	9.97	2,480	4,220	280
	17	Walker Creek	15.00	3,760	6,400	620
Va-7a-6	2	Sinking Creek	29.85	7,500	12,750	610
Va-7a-7	4	Little Walker Creek	17.59	4,410	7,510	300
Va-7a-8	18*	Trib. S. Fk. Reed Creek	3.33	820	1,420	130
	10*	Reed Creek	45.37	11,620	18,870	910
	11	Glade Creek	7.35	1,800	3,140	180
	17*	Stony Fork	6.17	1,510	2,630	130
	19	Mill Creek	13.51	3,320	5,760	350
	22	Cove Creek	25.90	6,350	11,050	380
Va-7a-13	9	Mill Creek	14.20	3,480	6,060	280
	10*	Crigger Creek	14.58	3,580	6,220	300
	11*	Blue Spring Creek	15.89	3,900	6,780	360
	12	White Rock Creek	5.09	1,250	2,170	110
Va-7a-14	5	Middle Fox Creek	19.35	4,750	8,260	320
	6	Fox Creek	36.67	9,000	15,650	490
Va-7a-16	2*	Meadow Creek	10.08	2,470	4,300	240
	10*	Coal Creek	7.62	1,870	3,250	200
	13*	Chestnut Creek	16.20	3,970	6,910	420
	14*	Trib. of Meadow Creek	2.83	690	1,210	100
Va-7a-17	5	Crooked Creek	8.13	2,000	3,470	180
Va-7a-18	3	Little Reed Island Creek	21.84	5,360	9,320	350
	16*	Mill Creek	5.33	1,310	2,280	100
Va-7a-19	5	Greasy Creek	42.46	10,420	18,120	480
	9	Snake Creek	17.93	4,400	7,650	350
	10*	Big Reed Island Creek	31.81	7,800	13,570	640
	11	Laurel Fork	22.74	5,580	9,700	310
	21*	Burks Fork	21.99	5,390	9,380	390
	22*	Pine Creek	3.40	840	1,450	90
Va-7a-20	2	Meadow Creek	9.71	3,400	3,120	220
	5	Big Indian Creek	17.05	4,180	7,270	350
	6	Beaver Creek	9.89	2,430	4,220	180
	7*	West Fork Little River	39.59	9,710	16,890	680
	8	Dodd Creek	16.56	4,060	7,070	340
	12	Brush Creek	11.26	2,760	4,800	300
	15*	Little River	42.91	10,530	18,310	830
	17	Oldfield Creek	4.33	1,060	1,850	90
WVa-7a-10	1	Island Creek	12.35	3,100	5,200	240
WVa-7a-11	1	Hands Creek	22.81	5,720	9,730	210
	4	Dropping Lick Creek	11.28	2,830	4,810	170
	5	Turkey Creek	17.07	4,280	7,280	230
WVa-7a-12	1	Brush Creek	10.90	2,730	4,650	140
	2	Rich Creek	26.00	6,320	11,290	820
WVa-7a-18	7	Mud Fork	10.46	2,620	4,470	230

NOTE: This data is from a U.S.D.A. interim report for the Upper New River Subbasin of the Kanawha River Comprehensive Study. The data is preliminary and is subject to change in the final report for the Kanawha River Basin.

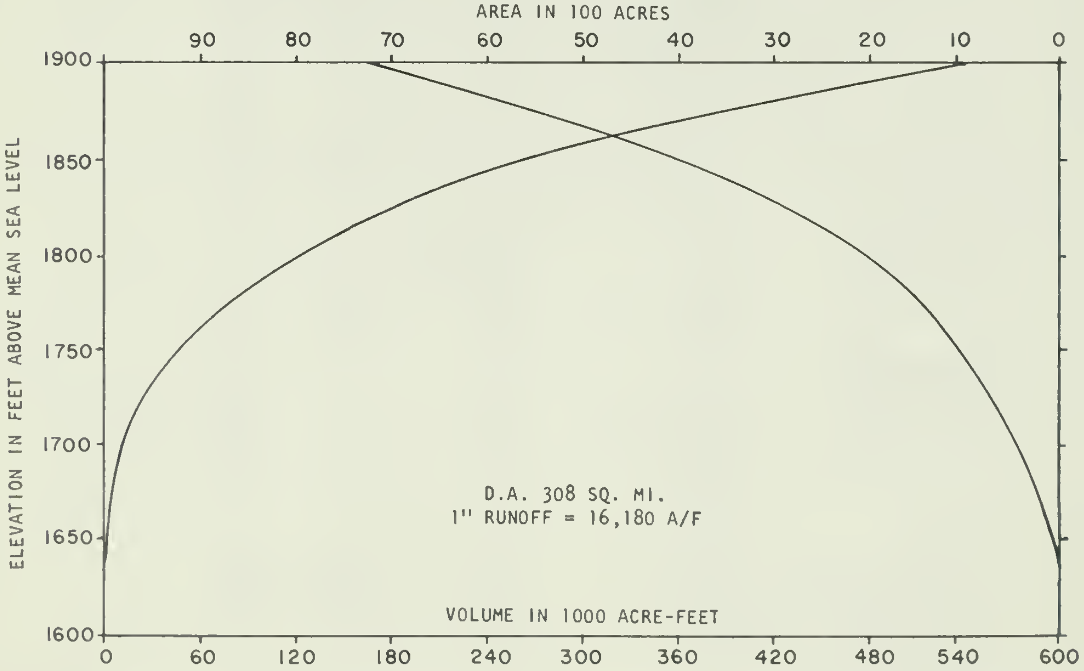
1/ At crest of emergency spillway

* Outstanding for recreation development

SITE 52-D - WALKER CREEK NEAR PEARISBURG



SITE 52-V - WALKER CREEK NEAR PEARISBURG



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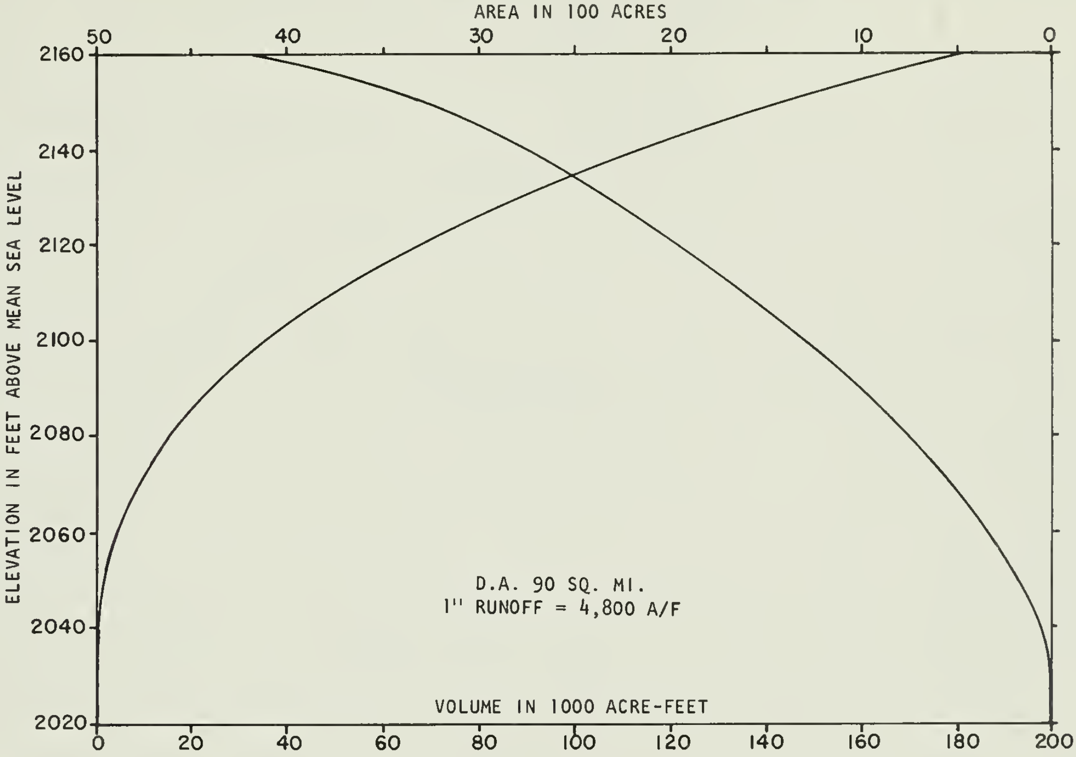
STAGE-STORAGE AND STAGE-AREA CURVES	DE.	DR. M.N.F.	APP.	REV.	NO.

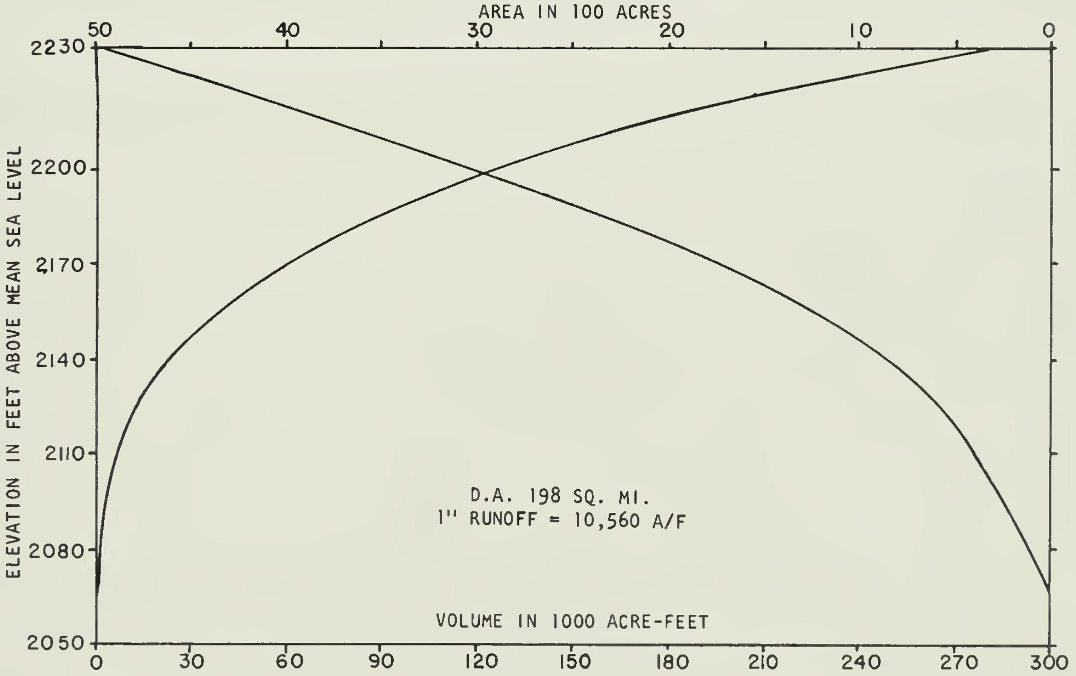
PLATE NO. 3

SITE 55 - KIMBERLING CREEK NEAR MECHANICSBURG



D.A. 90 SQ. MI.
1" RUNOFF = 4,800 A/F

SITE 59 - LITTLE RIVER NEAR RINER



D.A. 198 SQ. MI.
1" RUNOFF = 10,560 A/F

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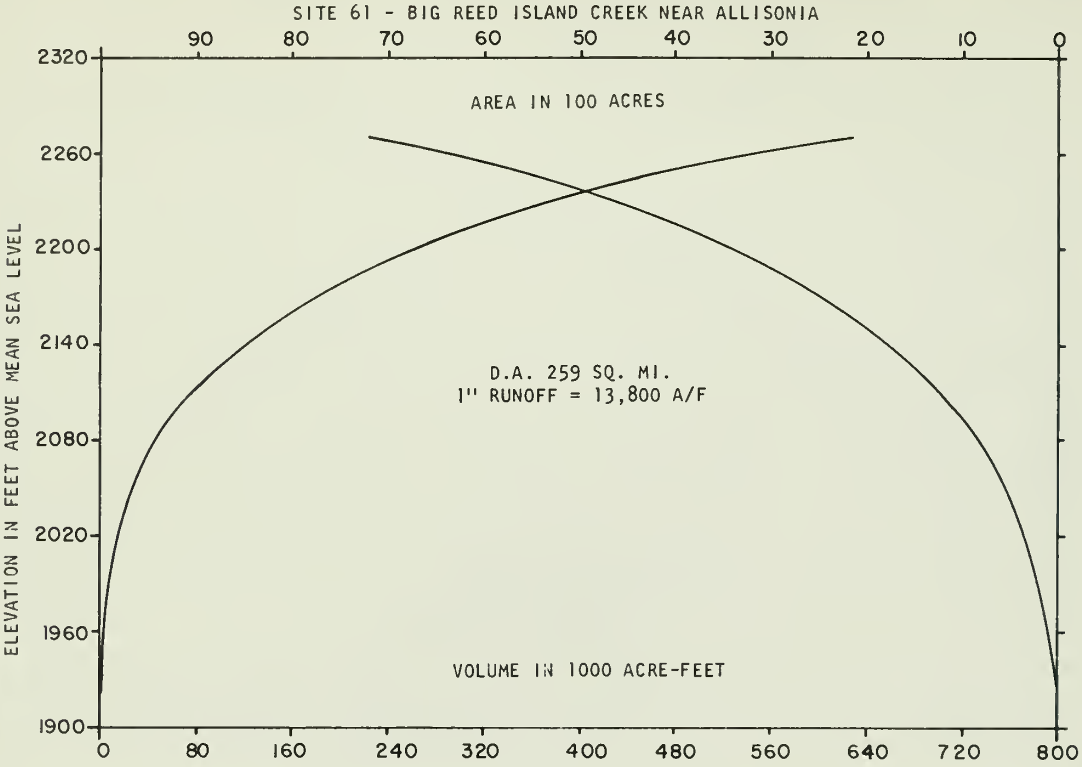
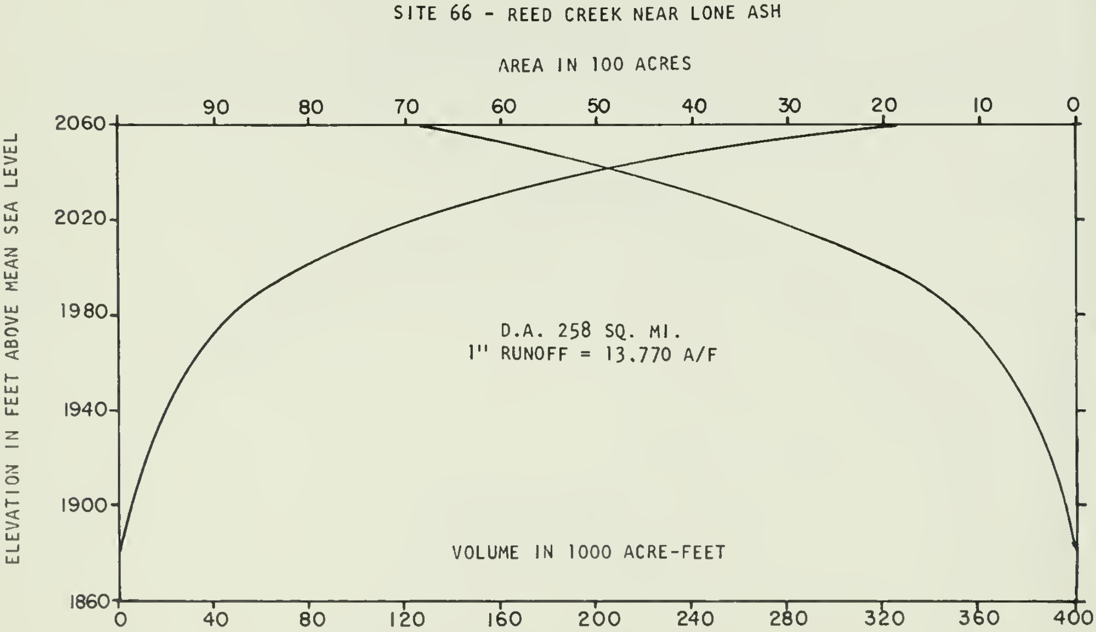
STAGE-STORAGE AND STAGE-AREA CURVES	DE.	DR. M.N.F.	APP.	REV.	NO.

PLATE NO. 4


SITE 61 - BIG REED ISLAND CREEK NEAR ALLISONIA


SITE 66 - REED CREEK NEAR LONE ASH

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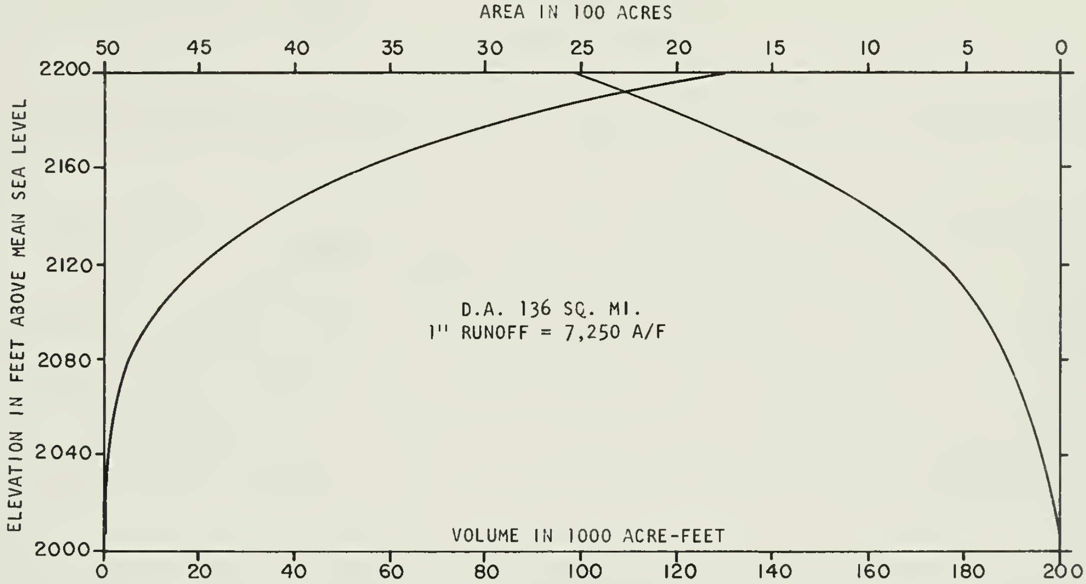
STAGE-STORAGE AND STAGE-AREA CURVES	DE.	DR. M.N.F.	APP.	REV.	NO.

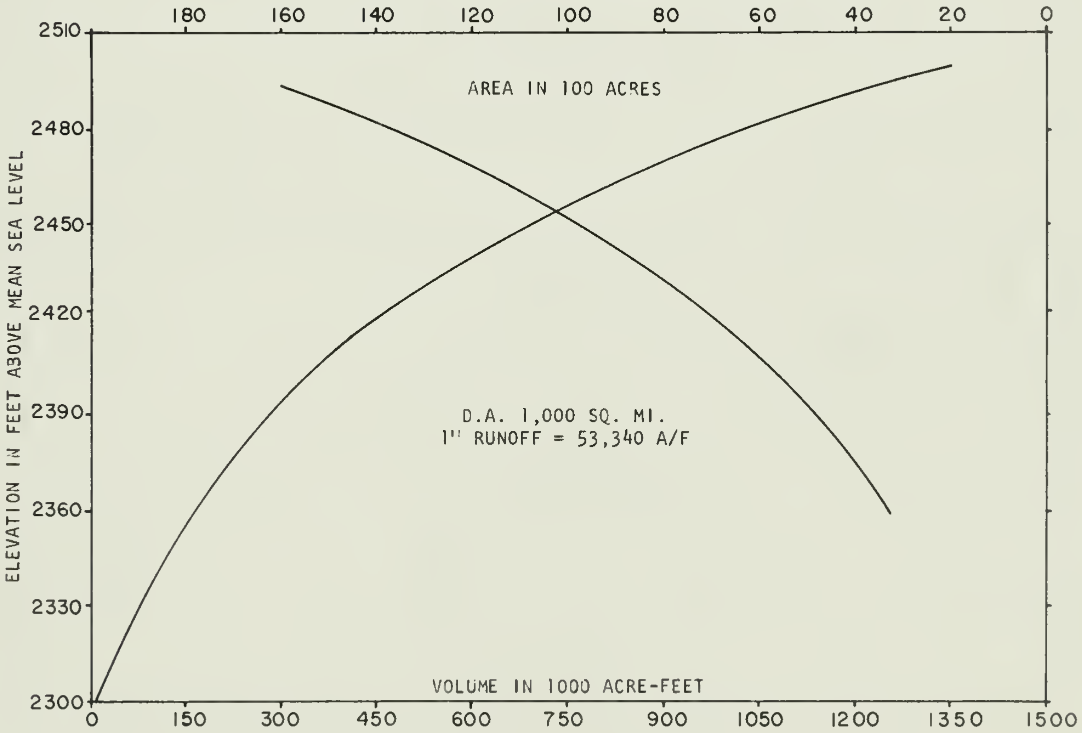
PLATE NO. 5

SITE 68 - CRIPPLE CREEK NEAR IVANHOE



D.A. 136 SQ. MI.
1" RUNOFF = 7,250 A/F

SITE 71 - NEW RIVER NEAR INDEPENDENCE (MOORE'S FERRY)



D.A. 1,000 SQ. MI.
1" RUNOFF = 53,340 A/F

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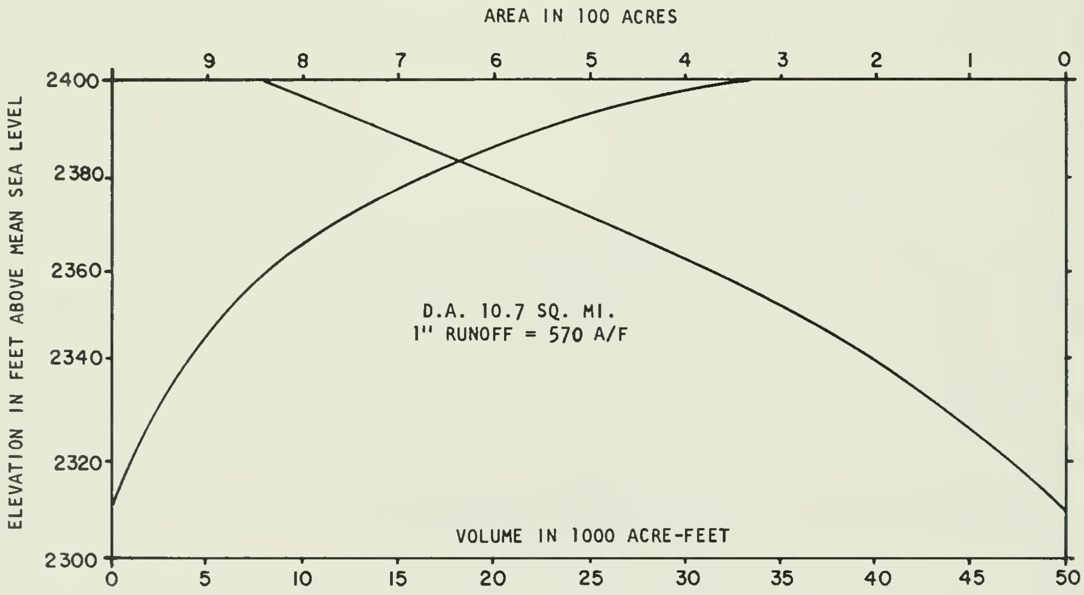
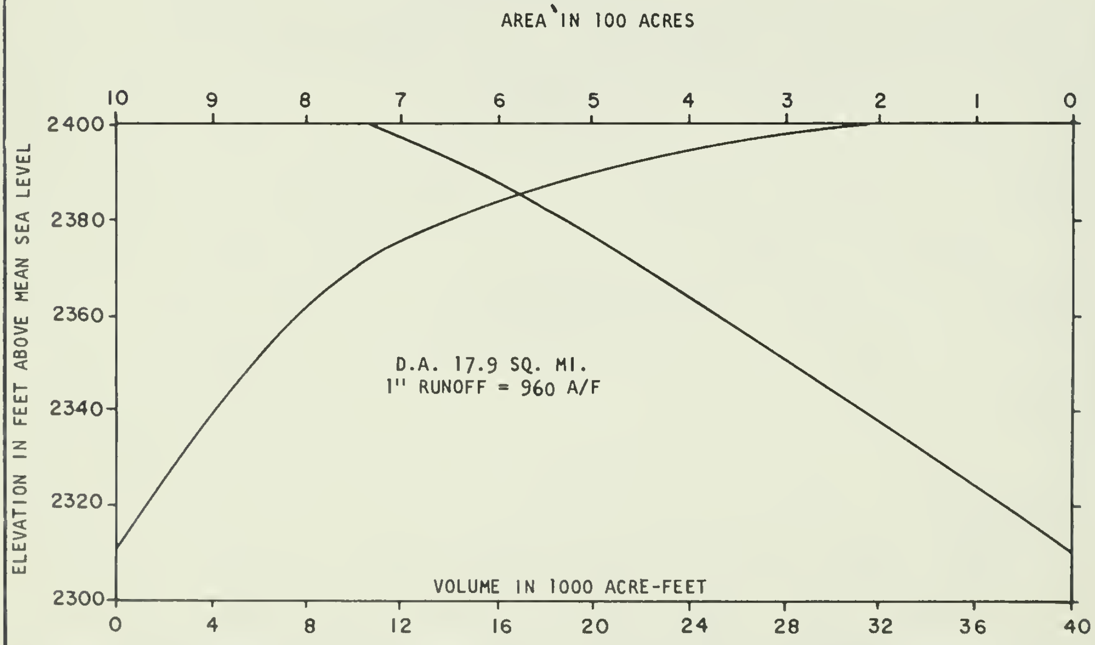
PLATE NO. 6

SITE 100 - BRUSH FORK NEAR FALLS MILLS



SITE 101 - MUD FORK NEAR FALLS MILLS



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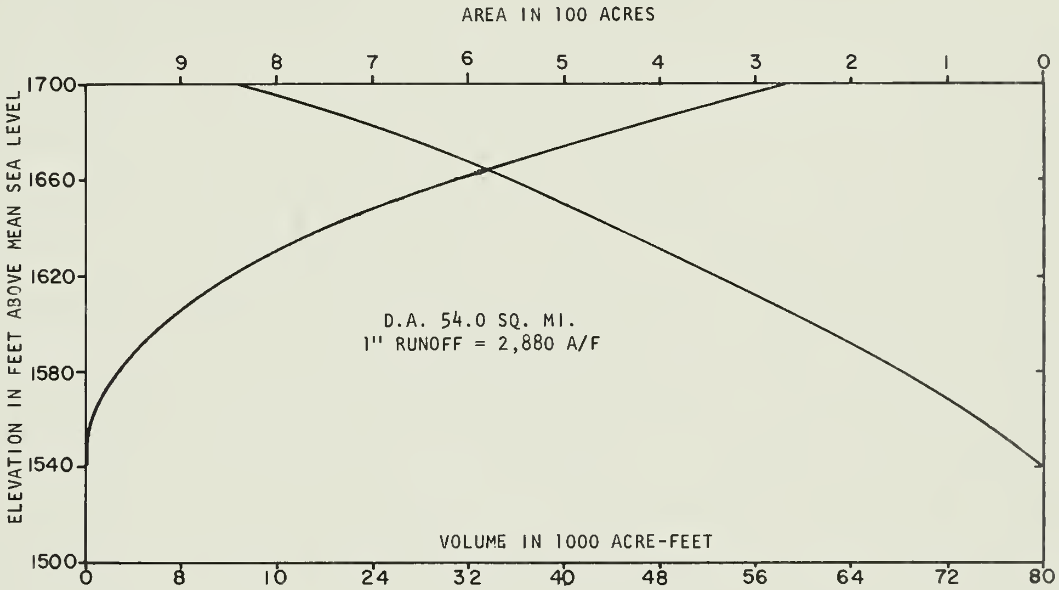
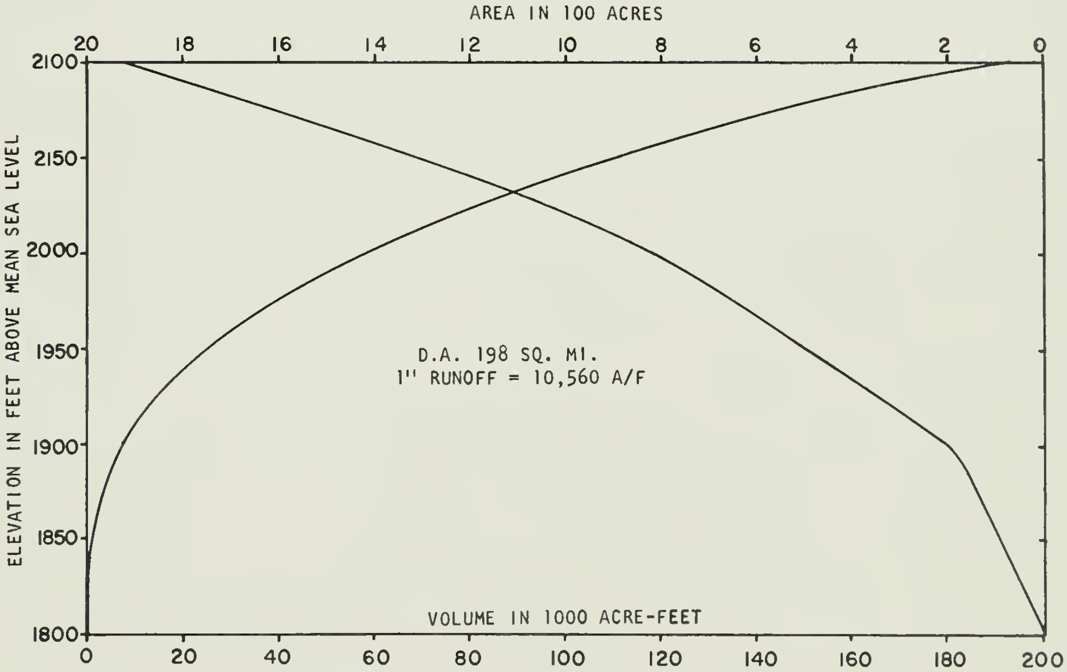
STAGE-STORAGE AND STAGE-AREA CURVES	DE.	DR. M.N.F.	APP.	REV.	NO.

PLATE NO. 7

SITE 105 - RICH CREEK ABOVE RICH CREEK



SITE 106 - LOWER WOLF CREEK ABOVE BOXLEY



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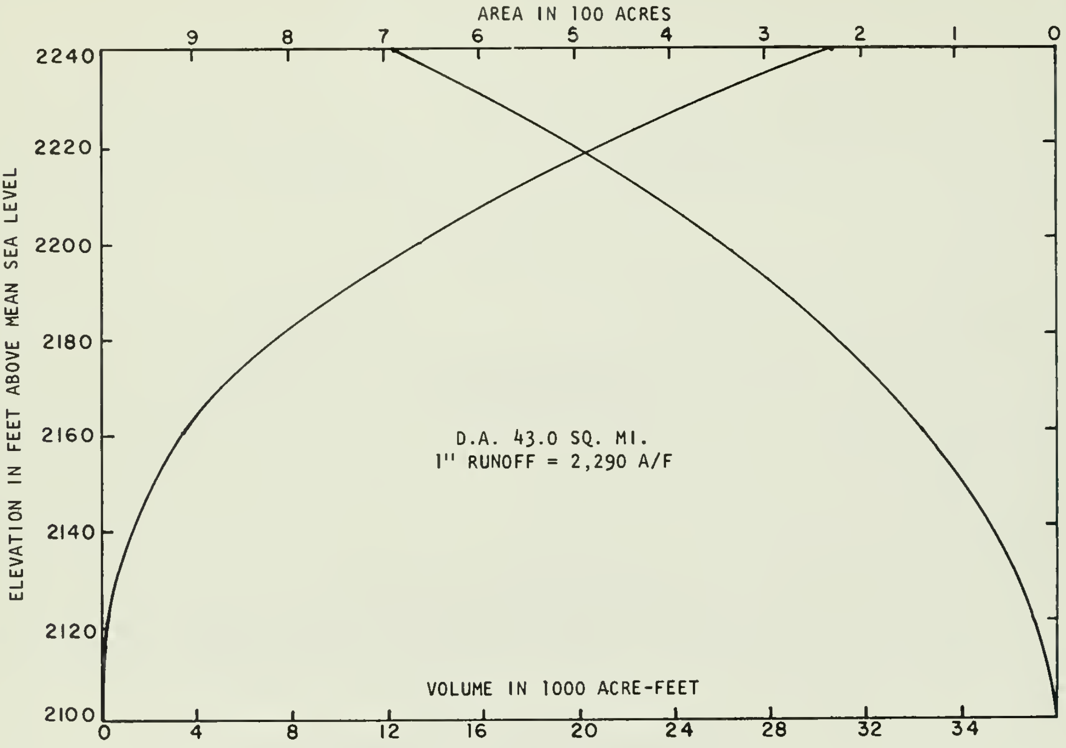
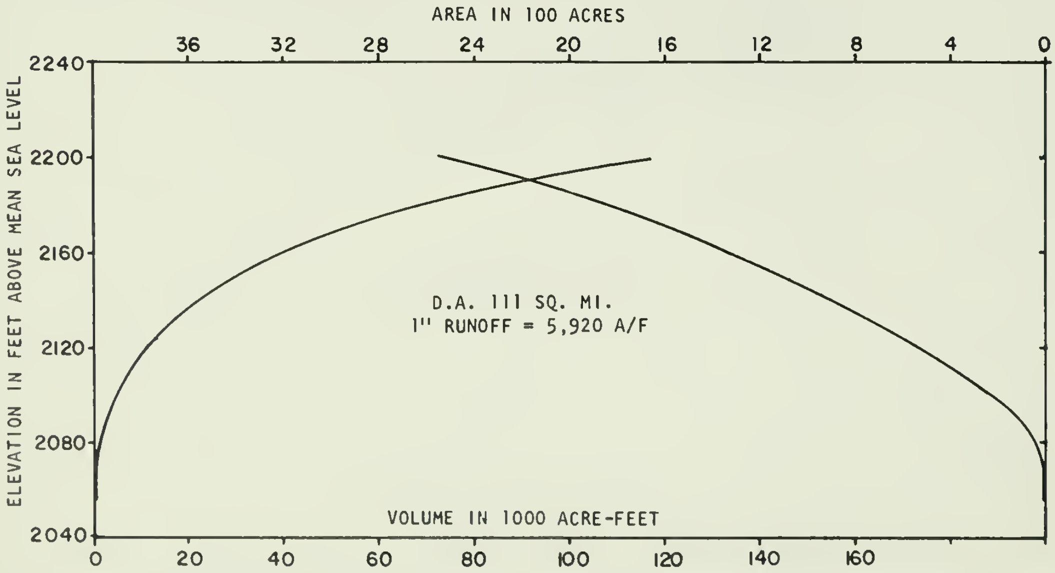
STAGE-STORAGE AND STAGE-AREA CURVES	DE.	DR. M.N.F.	APP.	REV.
				NO.

PLATE NO. 8

SITE 108 - CLEAR FORK ABOVE ROCKY GAP



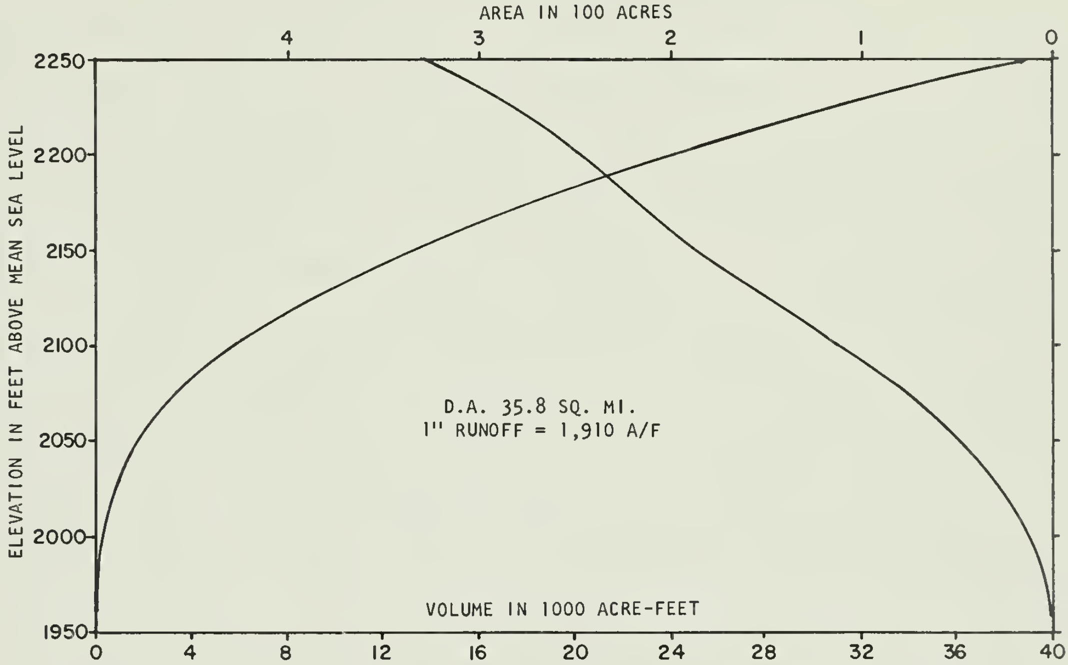
SITE 109 - UPPER WOLF CREEK AT SOUTH GAP



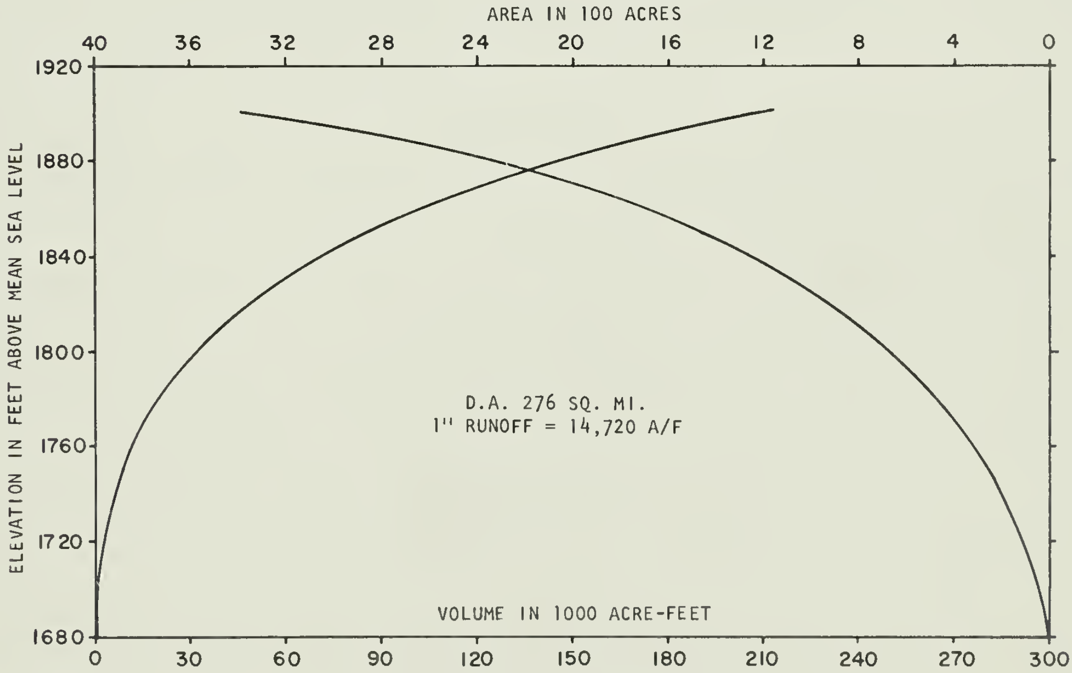
DIVISION OF WATER RESOURCES	SC.		DATE 9-19-67	SHT. 1	OF 1
STAGE-STORAGE AND STAGE-AREA CURVES	DE.	DR. M.N.F.	APP.	REV.	NO.

PLATE NO. 9

SITE 112 - STONY CREEK NEAR KERNS



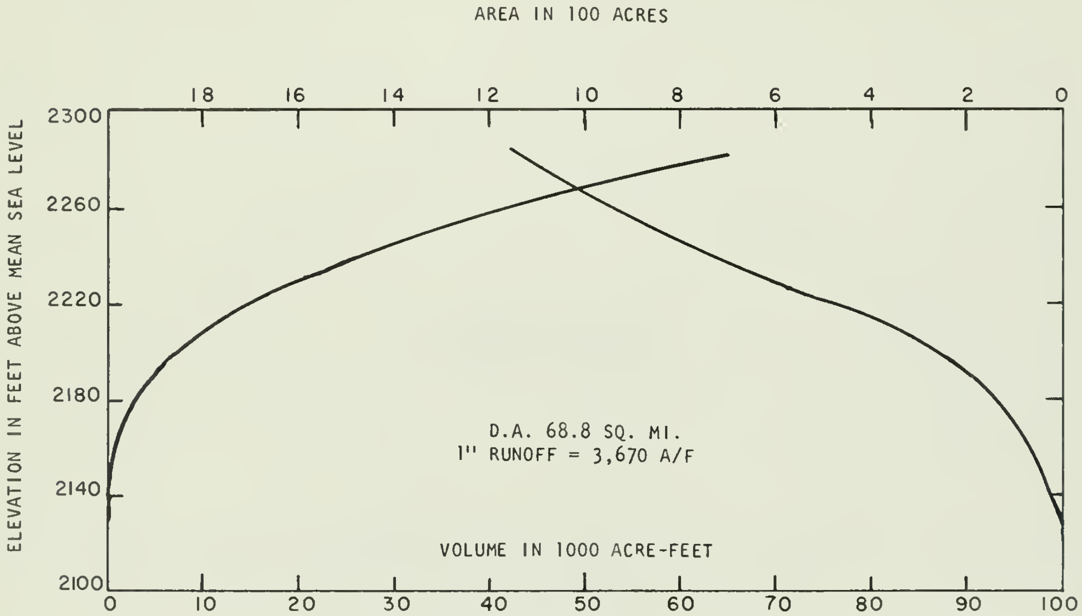
SITE 115 - LOWER WALKER CREEK NEAR BANE



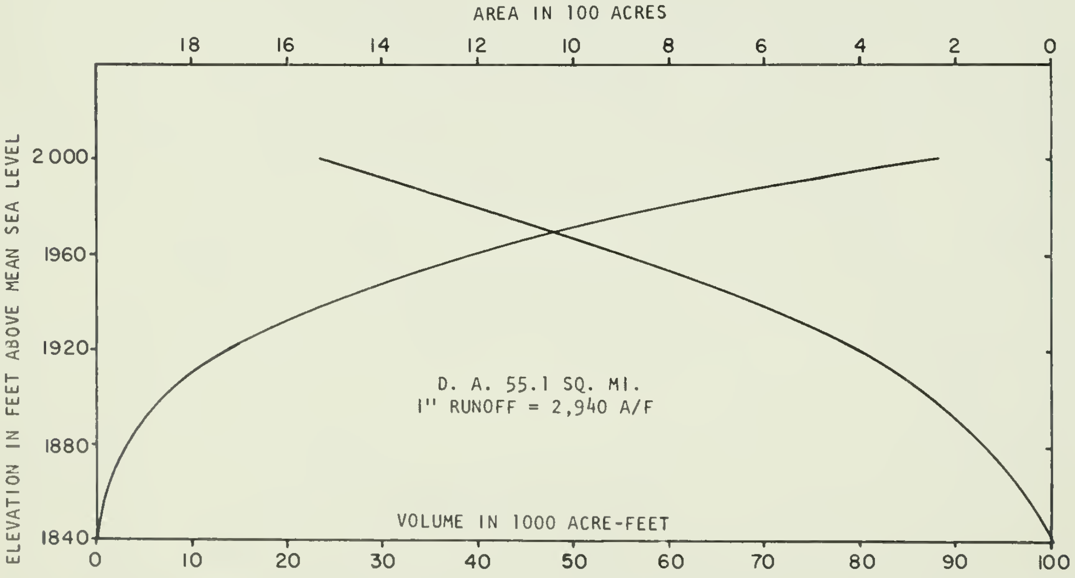
DIVISION OF WATER RESOURCES	SC.		DATE 9-19-67	SHT. 1	OF 1
STAGE-STORAGE AND STAGE-AREA CURVES	DE.	DR. M.N.F.	APP.	REV.	NO.

PLATE NO. 10

SITE 117 - WALKER CREEK ABOVE MECHANICSBURG

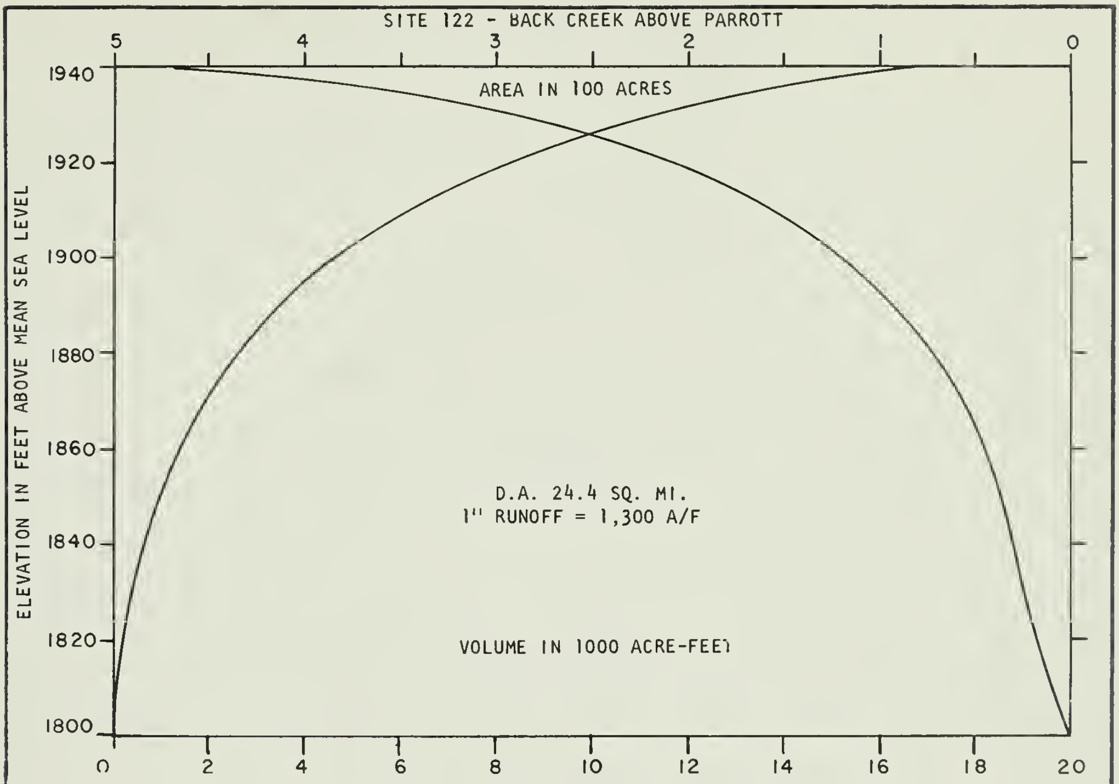


SITE 119 - LITTLE WALKER CREEK NEAR FRENCH'S CHAPEL



DIVISION OF WATER RESOURCES STAGE-STORAGE AND STAGE-AREA CURVES	SC.	DATE 9-19-67	SHT. 1	OF 1
DE.	DR. M.N.F.	APP.	REV.	NO.

PLATE NO. 11



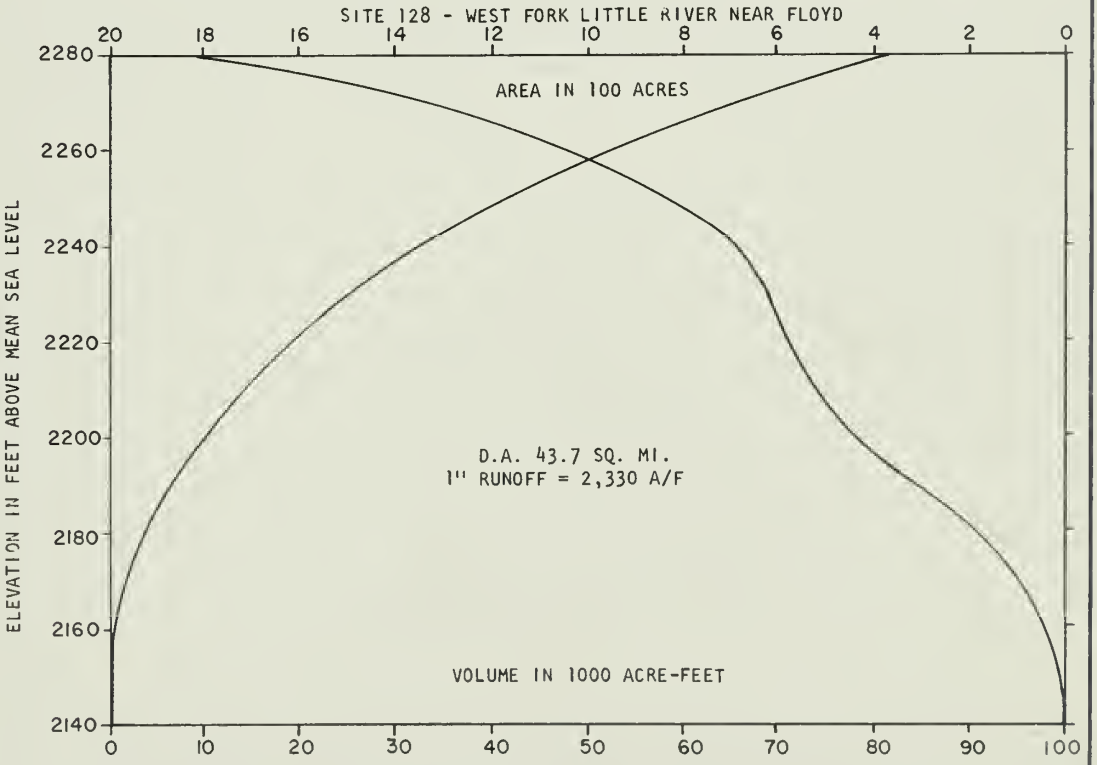


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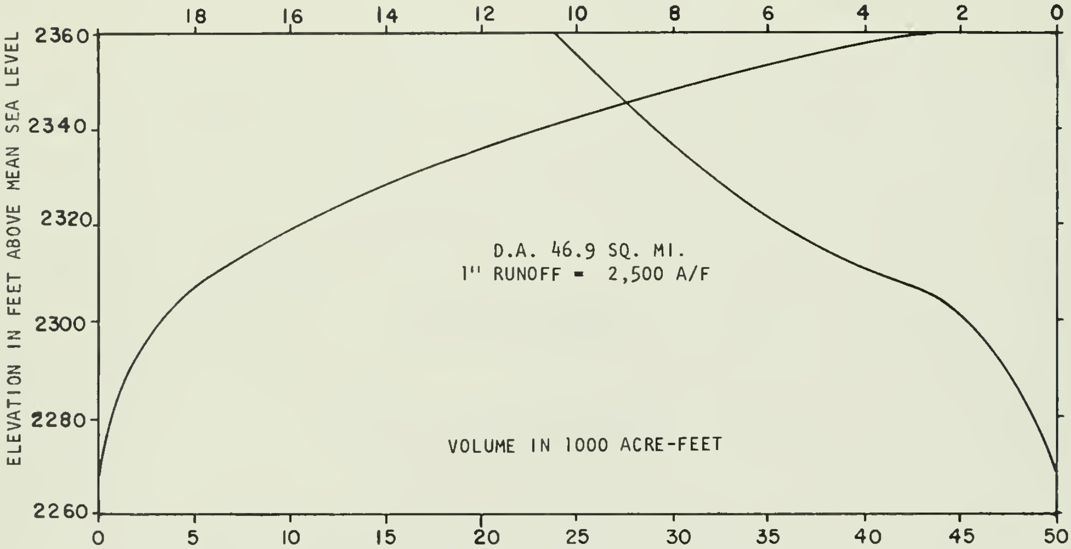
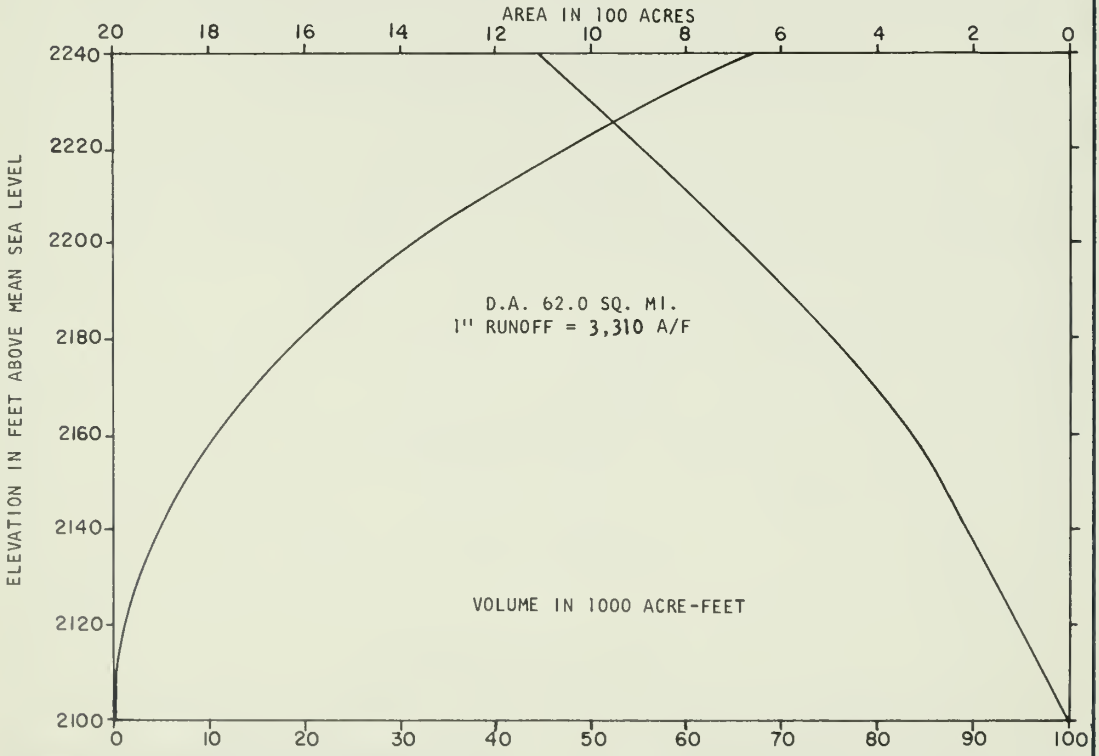
PLATE NO. 12

SITE 130 - UPPER LITTLE RIVER NEAR WOODS STORE



SITE 141 - LITTLE REED ISLAND CREEK NEAR SYLVATUS



DIVISION OF WATER RESOURCES	SC.	DATE 9-19-67		SHT. I	OF I
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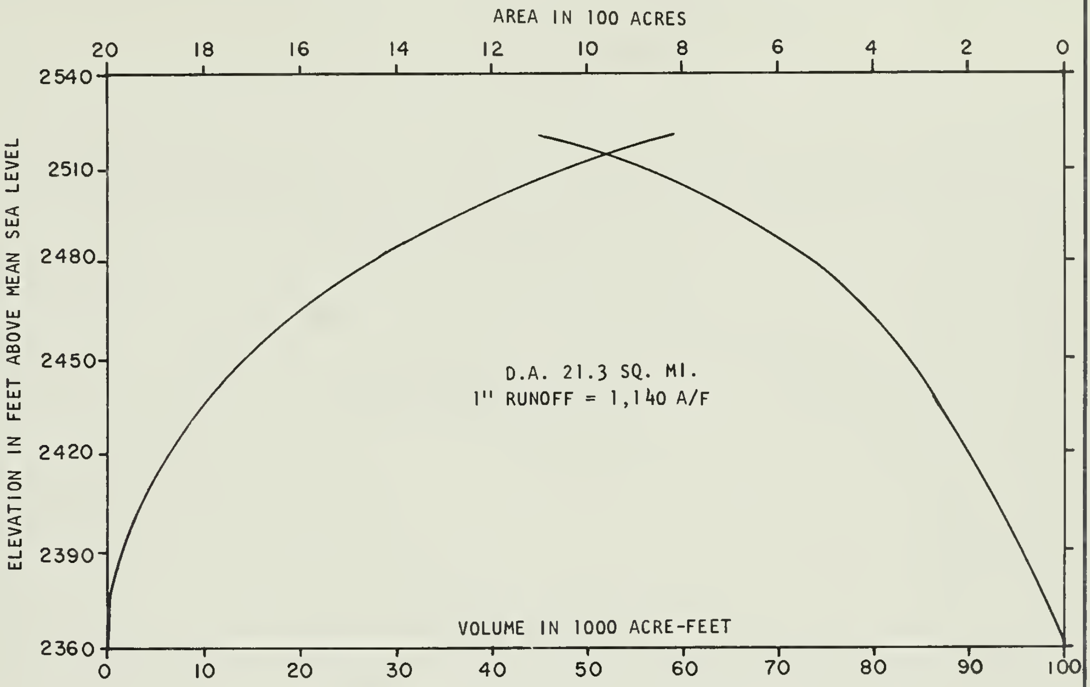
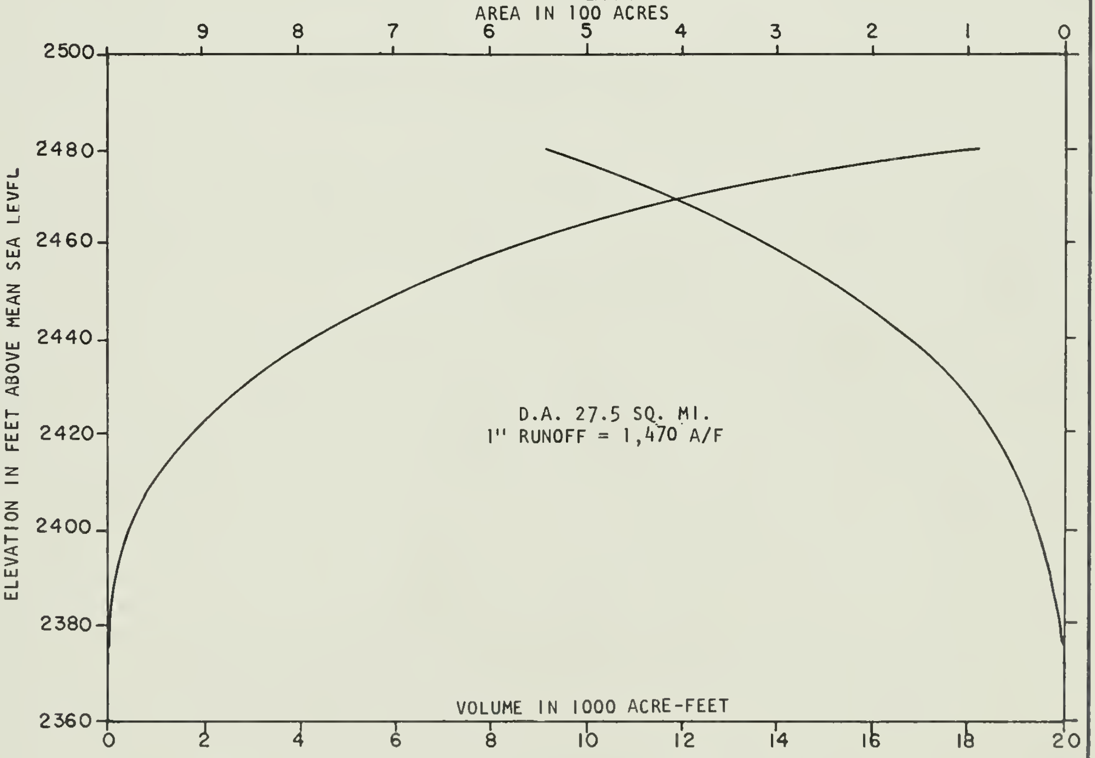
PLATE NO. 13

SITE 142 - UPPER LITTLE REED ISLAND CREEK NEAR HILLSVILLE



SITE 144 - BURKS FORK NEAR MT. HEBRON CHURCH



DIVISION OF WATER RESOURCES	SC.	DATE 9-19-67	SHT. 1	OF 1	
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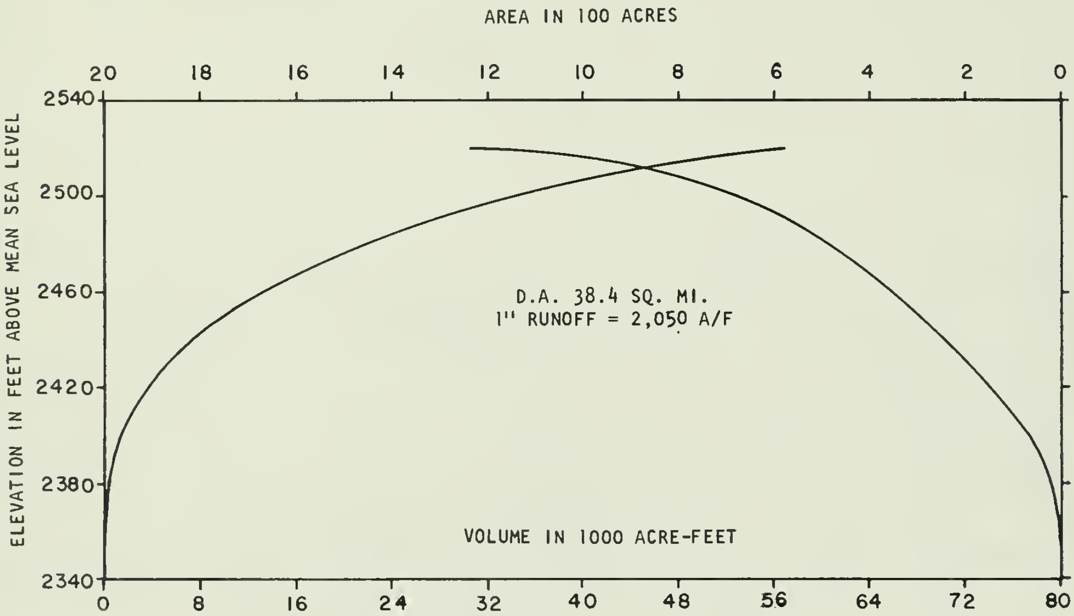
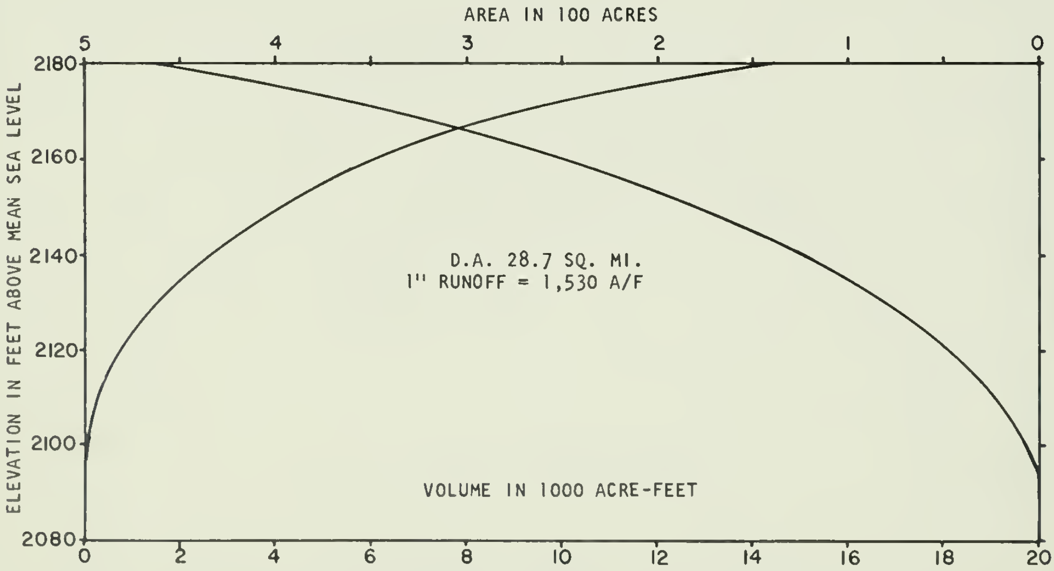
PLATE NO. 14

SITE 146 - UPPER BIG REED ISLAND CREEK NEAR GLADESBORO



SITE 151 - COVE CREEK NEAR BETHEL



DIVISION OF WATER RESOURCES | SC. | DATE 9-19-67 | SHT. 1 | OF 1
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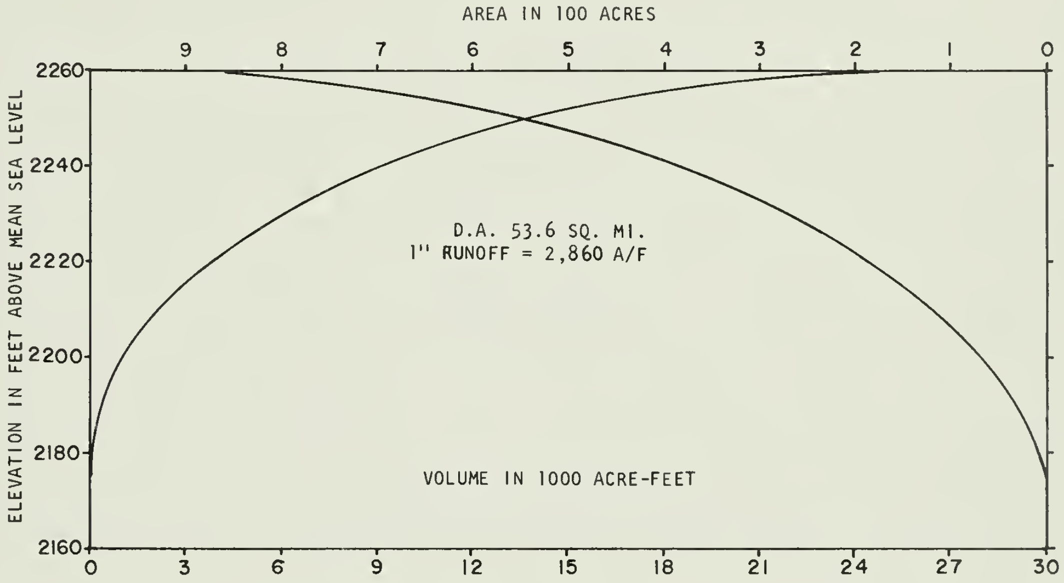
PLATE NO. 15

SITE 154 - UPPER REED CREEK ABOVE WYTHEVILLE



SITE 162 - BLUE SPRING CREEK BELOW CEDAR SPRINGS

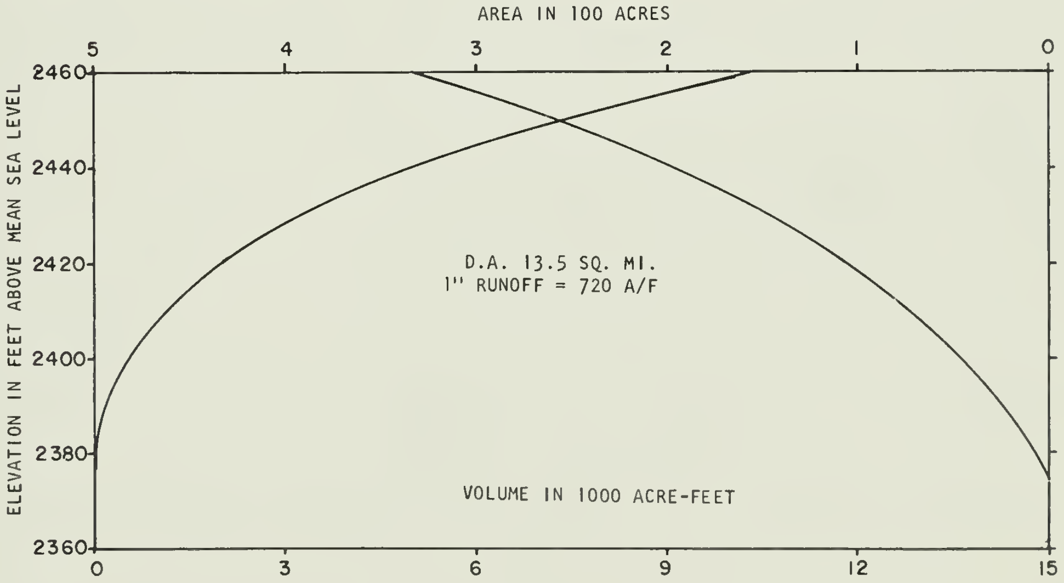


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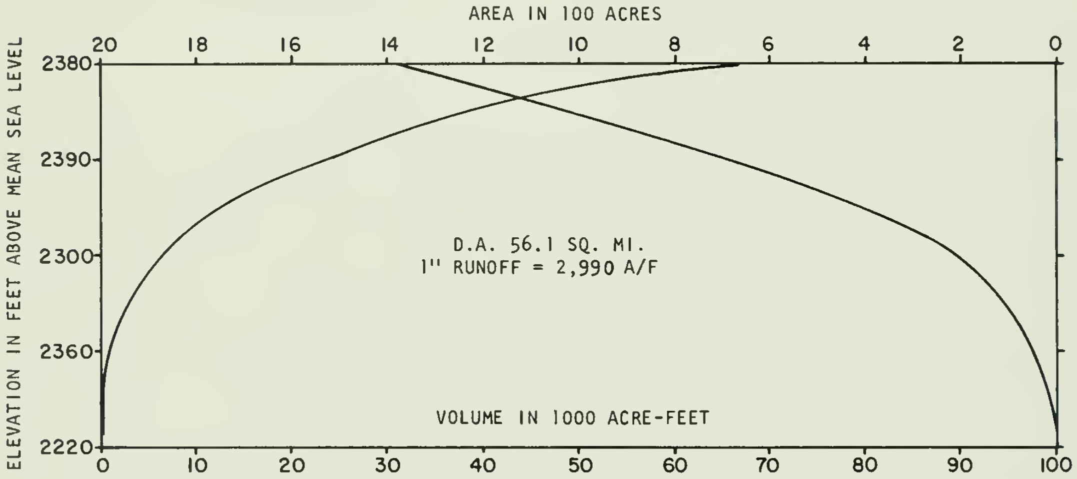
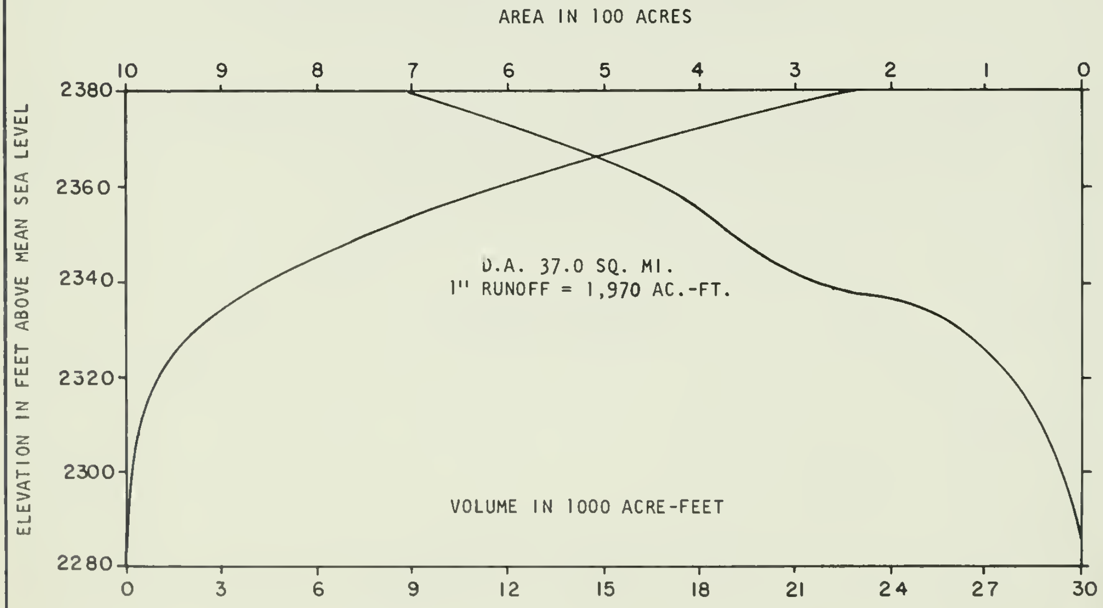
PLATE NO. 16

SITE 167 - LOWER CROOKED CREEK NEAR HEBRON



SITE 168 - UPPER CROOKED CREEK NEAR WOODLAWN



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STAGE-AREA CURVES

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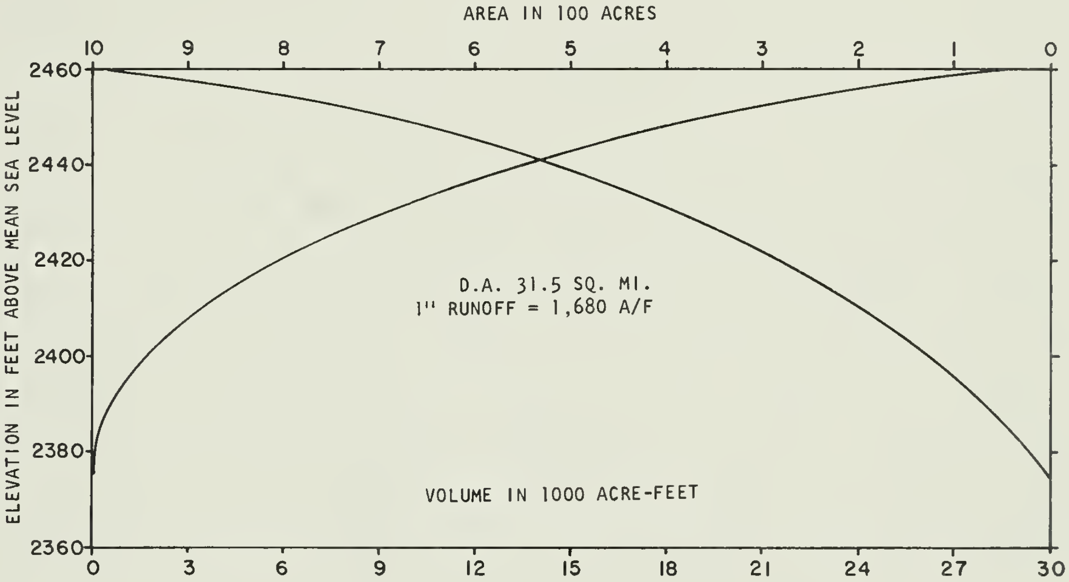
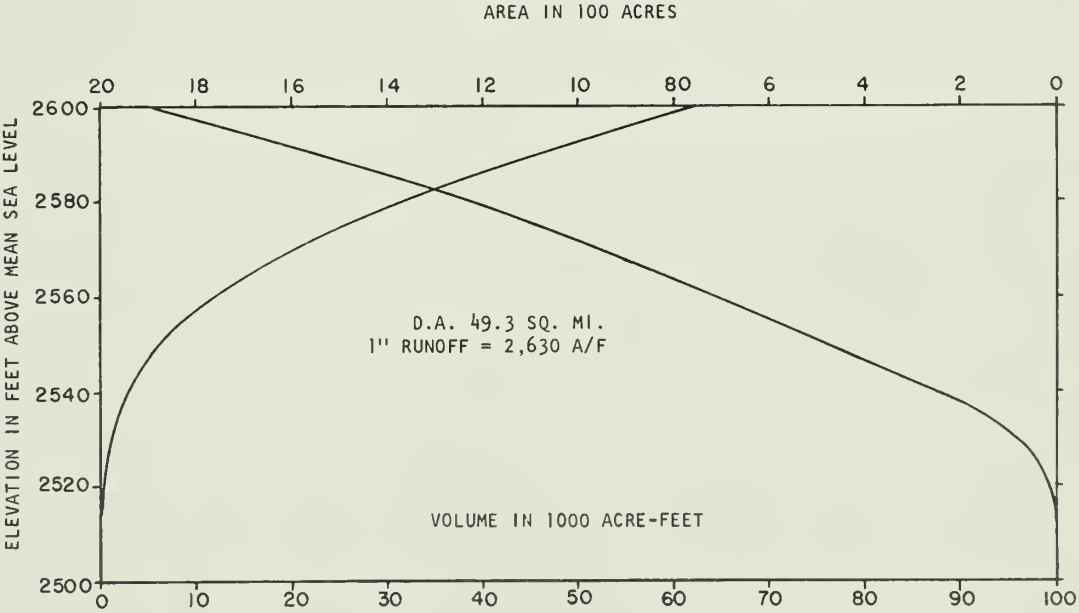
PLATE NO. 17

SITE 173 - CHESTNUT CREEK NEAR GALAX



SITE 178 - ELK CREEK NEAR LOWER ELK CREEK



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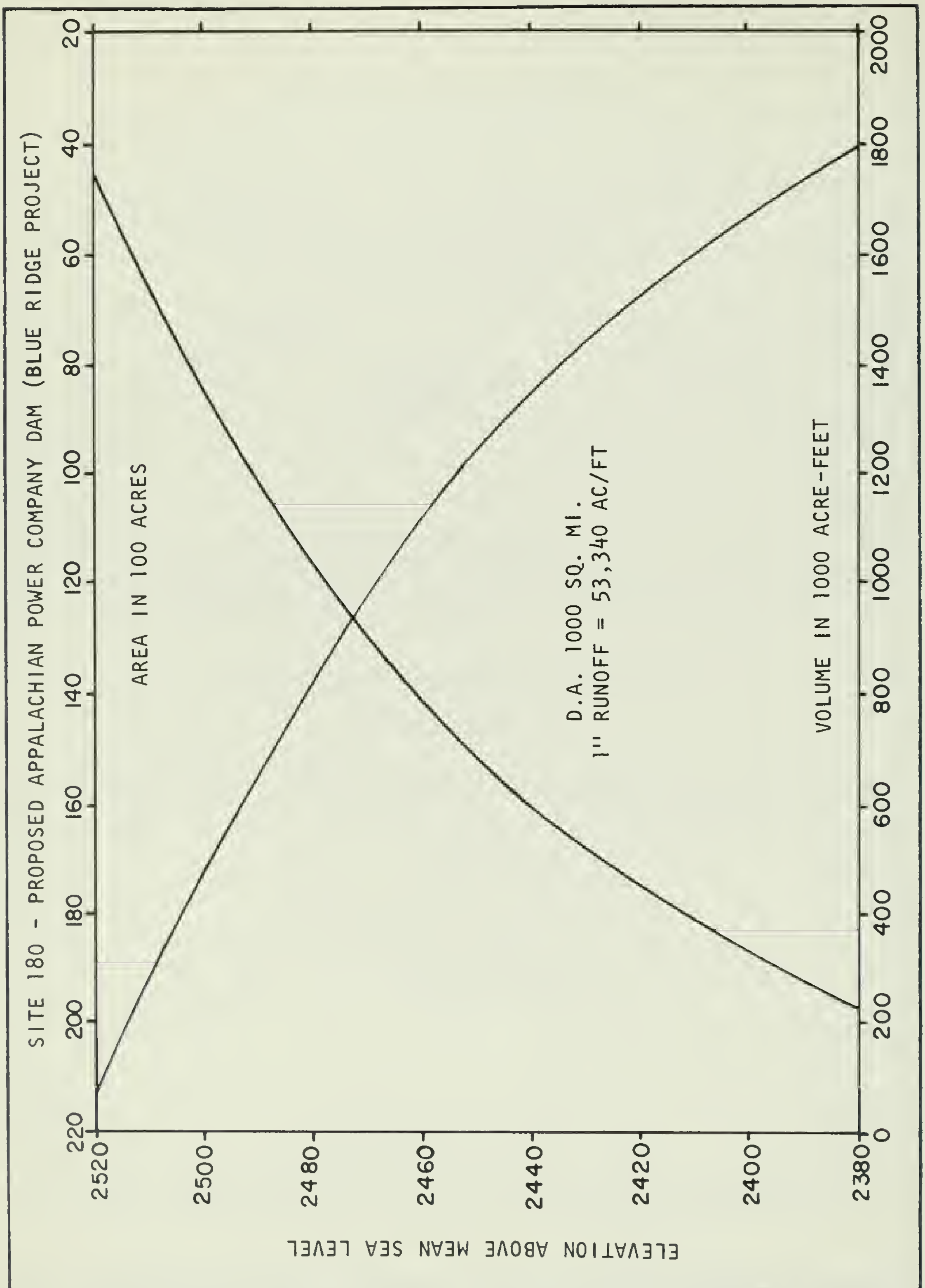
STAGE-STORAGE AND STAGE-AREA CURVES	DE.	DR. M.N.F.	APP.	REV.	NO.

PLATE NO. 18



SITE 180 - PROPOSED APPALACHIAN POWER COMPANY DAM (BLUE RIDGE PROJECT)

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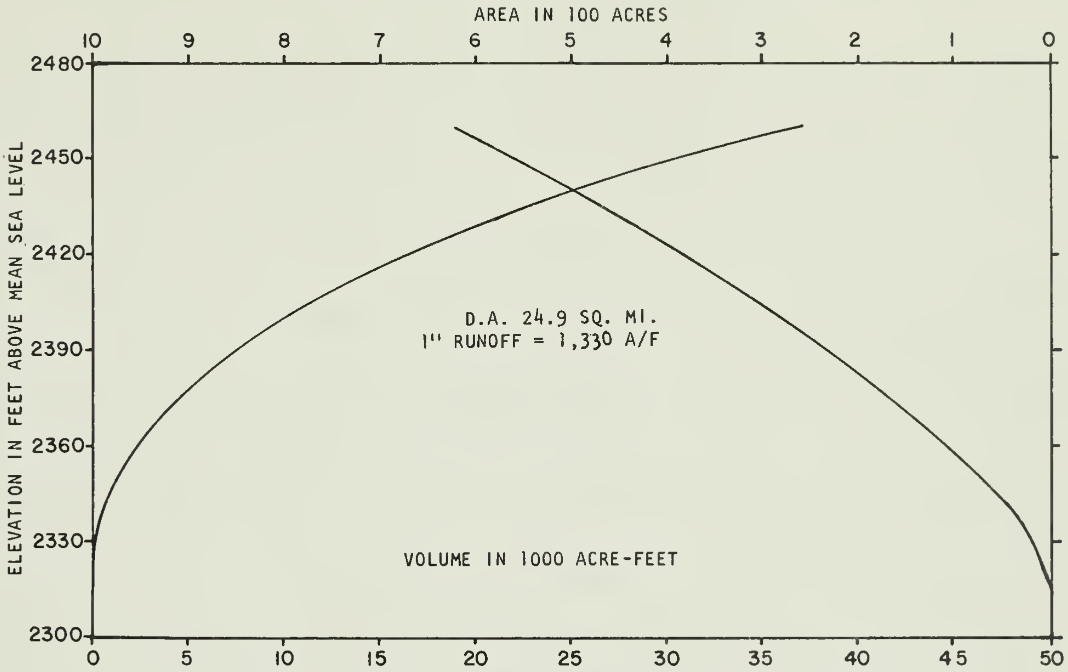
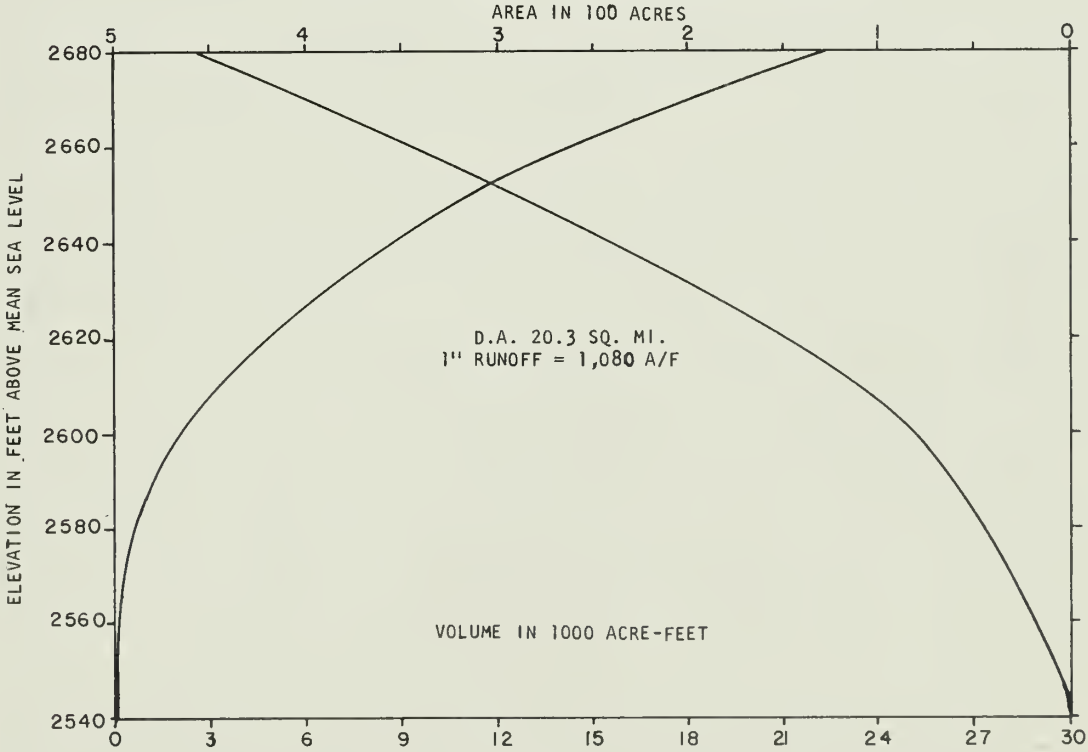
SITE 185 - PEACH BOTTOM CREEK BELOW INDEPENDENCE



SITE 191 - MIDDLE FOX CREEK NEAR BARTON CROSSROAD



DIVISION OF WATER RESOURCES	SC.		DATE 9-19-67	SHT. 1	OF 1
STAGE-STORAGE AND STAGE-AREA CURVES	DE.	DR. M.N.F.	APP.	REV.	NO.

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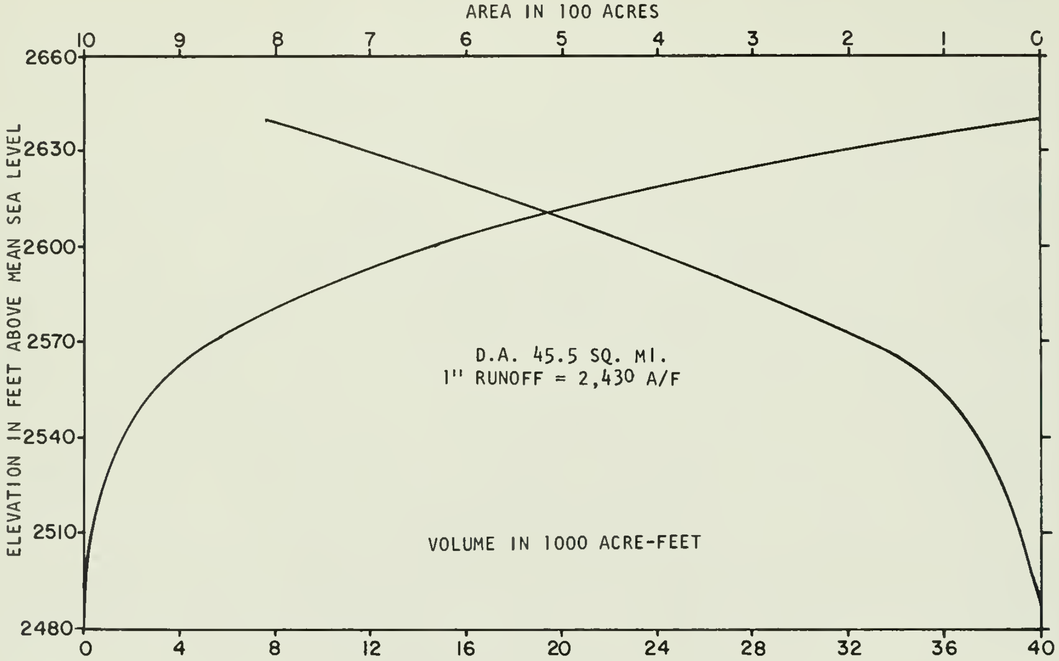
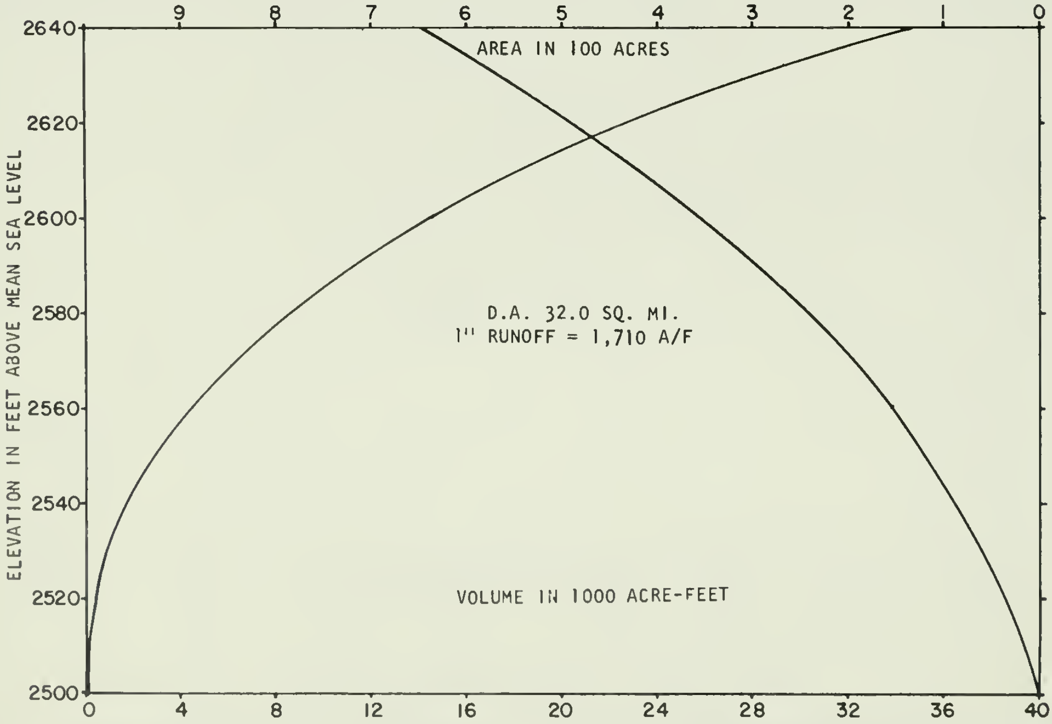
SITE 193 - FOX CREEK



SITE 196 - WILSON CREEK NEAR MOUTH OF WILSON



DIVISION OF WATER RESOURCES	SC.	DATE 9-19-67		SHT. 1	OF 1
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PLATE NO. 21

CHAPTER II

WATER SUPPLY AND POLLUTION CONTROL REQUIREMENTS IN THE NEW RIVER BASIN

Public Water Supply Section I

Volume IV of the New River Basin Comprehensive Plan contains the projected water supply requirements for the Basin. For the purposes of water supply and pollution study the Basin was separated into two sections. Section I (Upper Section) was defined as that area which is tributary to the New River above Claytor Dam. Section II (Lower Section) is the area tributary to the New River below Claytor Dam. The needs in Section I are anticipated to be approximately 45 percent of both the private and public water supply demand in the Virginia Basin.

A summary of projected public water supply demand follows. The demands are based upon the best estimates of future population growth from Volumes II and IV.

Public Water Supply Demand - Section I

Year	Population	Demand-MGD
1970	40,500	5
1980	47,300	7
1990	63,000	10
2000	75,075	12
2010	87,750	16
2020	111,315	21

A breakdown of the demand by major political subdivisions is expected to approximate the following allocations. The figures shown are average daily demands, and demands 50 to 100 percent higher may be expected during periods of peak usage. It should also be pointed out that the demands by locality in Section I do not carry as high a level of confidence as the overall Basin demands; however, the locality demands do provide a basis for long-range planning and alternative selection.

	1980	2000	2020
Carroll County	0.4	1.6	2.7
Grayson County	1.3	2.5	4.6
Pulaski County	1.8	2.7	4.5
Smyth County	0.04	0.08	0.14
Wythe County	1.8	3.1	5.7
Galax City	1.9	2.2	2.9

Note: All requirements in MGD

Availability of Water for Public Supply in Section I

Carroll County has several major tributaries which are adequate for supplying the quantity of water anticipated in 2020, and little development of the surface water resources is anticipated to meet public water supply demands. Ground water is available in Carroll County to meet localized minor demands or to supplement stream withdrawals. It is conservatively estimated that 25 percent of the 1980 demand could be supplied by ground water and 10 percent of the 2020 demand could be supplied from the ground-water resource.

A further refinement of the possibilities for ground-water supply in various areas of Section I and Section II will be found in the section of Chapter II entitled "Ground-Water Development Alternatives".

Grayson County has several small streams which are capable of meeting projected demands in 2020 if they are properly developed. Large impoundments will not be necessary; however, small impoundments for public water supply may be required. It is estimated that ground water in Grayson County can supply 25 percent of the 1980 demand and some 10 percent of the 2020 demand.

With the exception of Peak Creek, there are no major tributaries in Pulaski County; however, the main stem of the New River forms one boundary of the County and is adequate to meet all future water needs in the County. There is an abundance of ground water in a large portion of the County. Volume III of the New River Plan indicates possible well capacities of 100-500 gpm in the area. It is conservatively estimated that ground water in Pulaski County could supply at least 25 percent of the public water supply demand in 2020. It is believed that there will be no demand for major impoundments to meet the public water supply demand in Pulaski County.

Smyth County has no large tributaries. This County is quite rural and projected public water supply demands are not large. Well yields from properly located installations are expected to run from 20 to 49 gpm. Properly located well fields will supply estimated future water supply demands.

Wythe County contains two large tributaries, Cripple Creek and Reed Creek. Well installations in properly developed sites can be expected to yield between 50 and 100 gpm in favorable areas of the County. Some impoundment to meet public water demand in the Wytheville area is anticipated by the year 2000. The ground-water resource is estimated to be capable of supplying 10 percent of the demand in 2020.

The City of Galax is located on Chestnut Creek. This stream has an excellent base flow with the 1-day 30-year low flow being 0.31 CFS per square mile of drainage area or approximately 8 MGD.

From the standpoint of public water supply, it is doubtful that major impoundment of water by the City of Galax will ever be needed. Potential ground-water yield in the area is estimated between 20 and 99 gpm per installation.

Cost Estimates of Public Water Supply in Section I

Costs of public water supply are based upon unit cost of developing, treating, and distributing public water from a surface source and ground water source where ground-water use is indicated. All costs are in terms of 1965 dollars. It has been assumed that all existing systems are adequate to serve projected growth until 1980. The costs given are not final figures derived from detailed engineering study but are estimates for use in overall Basin planning. The costs reflect expenditures for principle and interest based on 20-year repayment schedule at 4½ percent interest, normal replacement, operation, and maintenance.

Years	Average Annual Cost (Million Dollars)	Capital Investment (Million Dollars)
1980-2000	1.1	13.
2000-2020	1.2	13.3

Private Water Supply in Section I

Private supply is defined as supply which is utilized by individual families not served by a public waterworks system. It is estimated that 45 percent of the total private demand in the Basin will be required in Section I. Volume IV of the Comprehensive New River Basin Plan contains estimated future demand in the Basin. The following table lists the quantities required in Section I.

Private Demand - Section I

Year	Demand-MGD
1970	2.7
1980	3.2
1990	4.1
2000	5.0
2010	5.9
2020	7.7

As a general rule, ground water is abundant in Section I, and there appear to be no foreseeable problems with quantity in satisfying the private supply demand from the ground water resource. Costs will vary according to the size and type of installation and will be borne by the individual user.

Industrial Water Supply Demand in Section I

Industrial demands in Section I are estimated as follows. These demands are those quantities required outside the public water supply systems. It is anticipated that industrial demand in Section I will approximate 5 percent of the total Basin industrial demand.

Year	Demand in MGD
1970	6
1980	10
1990	11
2000	15
2010	16
2020	20

Availability of Water to Meet Industrial Demand in Section I

The main stem of the New River has sufficient water at all points to meet projected demands for industry in Section I. Smaller tributaries will not be capable of meeting large demands without some future development.

There are large quantities of ground water in certain areas

Section I, particularly portions of Pulaski and Montgomery Counties. It is expected that small "dry" industries not utilizing public supply will rely on ground-water sources.

Cost Estimates of Industrial Demand in Section I

The quality of water needed to meet industrial demands may require ranges of treatment varying from essentially no treatment to virtually complete removal of all chemical constituents. The following cost estimates are based upon unit costs (1965) of various waters used in industry and reflect consideration of the various types of industry expected in Section I.

Year	Average Annual Cost (Million Dollars)	Capital Investment (Million Dollars)
1980-2000	379,000	4.9
2000-2020	532,000	6.9

It has been assumed that existing systems are capable of meeting the demand until 1980. The above costs include expenditures for principle and interest based on 20-year repayment schedule at 4½ percent interest, normal replacement, operation and maintenance.

Biochemical Water Quality in Section I

At the present time, there are no major pollution problems along the main stem of the New River in Section I. Potential problem areas on the tributary streams are limited to Chestnut Creek below Galax and Peak Creek below the Town of Pulaski. The New River from its entrance in Virginia to the headwaters of Claytor Lake is a wide, shallow, turbulent stream interspersed at intervals with relatively small power pools. The reaeration capability of the New River in Section I is high, and under its elevated base flow (once-in-10-year minimum consecutive 7-day low flow of 340 CFS at Galax) has extensive capability to recover quickly from organic waste loading. At the present time, a large increase in biochemical oxygen demand (BOD) could be safely tolerated in the New River in Section I.

Future plans for River development in Section I may turn the New River above Fries into a vast lake system extending into North Carolina. Development now under consideration by the Appalachian Power Company (Blue Ridge Project) and the United States Army Corps of Engineers (Moore's Ferry Project) will, in the case of construction of either project, reduce the free running length of the New River to approximately 23.6 miles, 15.3 miles of which will be between Buck reservoir and the headwaters of Claytor Lake. The reach of the stream between the proposed lower dam of the Blue Ridge Project and the backwater of Byllesby Dam has a very high reaeration coefficient, and calculations indicate that the stream will recover rapidly from a low dissolved oxygen level to a level near saturation. The length of stream involved in this recovery will be between four and six miles under an assumption of a once-in-10-year minimum 7-day low flow. From a dissolved oxygen standpoint then, the New River in Section I is ideally suited for assimilation of rather large organic loads.

There is a complicating factor, however, which negates the high assimilation capacity of the River. This factor is Claytor Lake. The problem of lake assimilation of waste greatly differs from that of river assimilation. The governing elements of pollution in lakes are the nutrient concentrations which lakes can accommodate without suffering a loss of quality that would impair the usefulness of these bodies of water. An overabundance of nutrients in a lake will result in the growth of undesirable quantities of algae and other aquatic plant life. It is generally believed that undesirable concentrations of nitrogen and phosphorous play a key role in lake degradation. There are concentration levels of nitrogen and phosphorous which will also result in degradation of flowing streams; however, the amounts required for river degradation are generally much higher than the amounts required for lake deterioration.

The limiting factor of pollution in Section I for the foreseeable future will, therefore, be the ability of Claytor Lake and future lakes to tolerate nutrient loading.

Magnitude of Existing Waste and Projection of Waste in Section I

The following table presents estimates of waste magnitude in 1965 and projections of waste from municipal and industrial sources in the future. The values given for BOD are for raw waste generated in or anticipated for generation in the watershed. The figures shown for nitrogen and phosphorous in 1965 are estimates of the quantity of these pollutants, from only sanitary waste effluents, discharged to the watershed. The estimates of future nitrogen and phosphorous quantities are estimates of the quantities that will be generated on the watershed in Section I from anticipated sanitary and industrial waste sources. The future estimates reflect a tremendous increase over figures shown for 1965. It should be emphasized, however, that existing figures are estimates on the basis of only domestic sewage and that future figures are reflections of what could occur from both sanitary and industrial waste.

Year	Pounds of 5-Day BOD per Day	Total Nitrogen Loading in Pounds Per Day	Total Phosphorous Loading in Pounds Per Day
1965		500	400
1980	24,500	4,100	3,100
1990	30,800	5,100	3,900
2000	36,300	6,000	4,500
2010	43,000	7,200	5,400
2020	51,500	8,600	6,400

The following tabulation indicates the estimated loading of nitrogen and phosphorous in Claytor Lake from sanitary waste sources in 1965 and industrial and sanitary waste sources in the future unless steps are taken to prevent the projected loadings.

Year	Total Nitrogen Loading in Pounds Per Year Per Acre of Normal Pool Area	Total Phosphorous Loading in Pounds Per Year Per Acre of Normal Pool Area
1965	42	30
1980	329	246
1990	438	330
2000	511	384
2010	584	438
2020	730	549

Future waste loading in Section I will be distributed throughout the upper section on the various tributaries. The problem of pollution on these tributaries will, for the most part, be the classical problem of BOD and associated depressions of dissolved oxygen. It is believed that with the exception of Peak and Chestnut Creek the natural stream flows in Section I will be adequate to accommodate future BOD loading and maintain good quality water in the tributaries if a high degree of secondary biological treatment is practiced.

As far as can be ascertained, the existing nutrient loading in Claytor Lake has not significantly impaired the quality of Claytor Lake for any purpose. The problem of nutrient enrichment of a lake is complex and the science of predicting the effects of nutrient loading is not exact. Based upon work by various researchers and the projected loading of nitrogen and phosphorous, it is estimated that serious water quality deterioration will be experienced by 1980 unless measures are taken to prevent this form of pollution. It should be clearly stated, however, that the levels indicated are not absolute and that possible difficulty may occur before the time indicated. As the waste loading on the watershed increases, monitoring of the tributary streams and waste discharges as well as the lake should be initiated in order that the "point of no return" of nutrient enrichment will not be reached. An extensive study of Claytor Lake to more clearly define its tolerance to pollution would be of great value.

A lake, unlike a flowing river, is difficult, if not impossible, to cleanse once pollution has become a problem; and as far as can be ascertained, there have been no lakes which have been satisfactorily reclaimed, as far as quality is concerned, after the danger point of enrichment has been reached.

The proposed Blue Ridge Project is well located as far as the projected waste discharge in Virginia is concerned. It is believed that projected waste loading to any large stem reservoir in this section from waste sources in Virginia will not seriously endanger the water quality in the reservoir for many years. The effects of waste discharge in the North Carolina portion of the New River watershed should be carefully evaluated since loading to any proposed reservoir from waste sources in North Carolina may pose the most significant threat to water quality in the lake.

In summary, therefore, the primary problem of pollution in the future in Section I of the New River Basin will be the nutrient enrichment of Claytor Lake. Because of the nature of lake enrichment, it will be necessary to control pollution before great difficulty is encountered. If Claytor Lake is to maintain its value, it is felt that large waste-producing industry would be better located in Section II.

Alternatives for Solution to Waste Problems in Section I

Three alternative solutions to future problems of enrichment in Claytor Lake suggest themselves:

(1) - Diversion of waste below Claytor Dam;

(2) - Advanced waste treatment to remove nutrients;

(3) - Combination of waste diversion and advanced waste treatment.

Advantages and disadvantages of each of the above courses of action outside of the economics of the alternatives are listed below:

Diversion of Waste below Claytor Dam

Advantages:

(1) - A more "fool proof" scheme of lake protection in which upsets in treatment plant efficiency will not affect the lake.

(2) - A greater degree of protection for tributaries which would otherwise be in jeopardy when large volumes of water are involved.

(3) - Maintenance of clean tributaries which may be needed at at later date for flow augmentation, water supply, recreation, and power production.

(4) - A greater level of upstream development could be accommodated than would be the case even if advanced waste treatment was used in Section I.

(5) - Costs can be more accurately determined and forecasts of the future effect of diversion can be made more reliably.

Disadvantages:

(1) - Probable need for area-wide projects if large diversion piping is constructed as opposed to independent action by upstream communities if diversion is not utilized.

This "disadvantage" is listed since much greater cooperation by all concerned is needed than would otherwise be the case.

(2) - Diversion of some water from the watershed in Section I in the form of waste or waste effluent and an associated loss of potential hydroelectric power and water supply.

(3) - There is a possibility that the City of Radford's water intake might require relocation.

Advanced Waste Treatment

Advantages:

(1) - Each area would be able to treat its own waste and take independent action without the necessity for a great deal of coordination with other political subdivisions.

(2) - Advanced waste treatment would result in better water quality all along the River instead of in just Section I.

Disadvantages:

(1) - The lake would be subject to degradation during intervals of treatment plant malfunctions.

(2) - The state of advanced waste treatment design is in its infancy and completely reliable systems may not be available until after the "danger point" of lake fertilization has been reached.

Combination of Waste Diversion and Advanced Waste Treatment

This course of action combines the advantages of the two alternatives previously indicated and eliminates most of the disadvantages. The primary advantage to be gained from this course of action is that it will permit orderly development of Section I and provide flexibility in handling future waste problems as they occur on the watershed.

Cost of Alternatives

Diversion of All Waste. The cost of diversion only has been based upon the construction of a large interceptor from a point one mile below Claytor Dam connecting the major population centers in the upper section. The following costs are based upon a 20-year repayment period at 4½ percent interest, normal operation, maintenance, and replacement. Two levels of waste treatment have been assumed: Primary - 35 percent BOD removal, and secondary - 85 percent BOD removal. It should be again stressed that the costs indicated are preliminary. The values shown are meant to indicate the general magnitude of cost and will permit evaluation of alternative solutions.

Diversion Plus Primary Treatment

Years	Average Annual Cost (Million Dollars)	Capital Investment (Million Dollars)
1980-2000	2.3	27.3
2000-2020	1.2	13.4

Diversion Plus Secondary Treatment

Years	Average Annual Cost (Million Dollars)	Capital Investment (Million Dollars)
1980-2000	2.5	31.2
2000-2020	1.7	19.4

The total assessed valuation of real estate in major political subdivisions in Section I was approximately 47.7 million in 1965. It is evident, therefore, that diversion alone would be a large financial burden, and in all likelihood could not be financed without considerable State and/or Federal aid. If waste is diverted below Claytor, it may be necessary to relocate the City of Radford's water intake and the Blacksburg-Christiansburg-V.P.I. Water Authority's intake to a point upstream of the final waste discharge.

Advanced Waste Treatment Only. The art of predicting advanced waste treatment costs is difficult, at best, because of the limited number of full-scale installations in service and the constantly changing technology of the field. It is assumed for purposes of this discussion that biological secondary treatment followed by nitrogen and phosphorous removal will be utilized. The removal of nutrients and the cost is based upon recent work at Lake Tahoe in California (Journal of the Water Pollution Control Federation, May 1967) and involves filtration, coagulation, and air stripping. Unit size of the process is standardized at five MGD for cost comparisons. Cost estimates for advanced waste treatment throughout Section I are shown in the following table. These costs include treatment of both sanitary and industrial waste.

Years	Average Annual Cost (Million Dollars)	Capital Investment (Million Dollars)
1980-2000	2.6	29
2000-2020	3.9	43

These figures indicate that advanced waste treatment alone in Section I will be considerably more expensive than diversion and secondary treatment to effect 85 percent BOD removal.

Combination of Diversion and Advanced Waste Treatment. The evaluation of costs under a scheme of waste diversion and advanced waste treatment is based upon an assumed large interceptor on the west side of the New River from a point one mile below Claytor Dam to Wytheville. These regions served are anticipated to be among the most rapidly growing areas in Section I. The waste diverted would require primary treatment. All other communities in Section I would be served by advanced waste treatment plants. Costs involved for the combined scheme of solution are indicated in the following table:

Years	Average Annual Cost (Million Dollars)	Capital Investment (Million Dollars)
1980-2000	2.0	20.3
2000-2020	2.2	16.2

These costs are in the general range of the "diversion only plus primary or secondary treatment".

Minimum Treatment Required in Section I and Cost

It is assumed that in order to protect tributary quality that secondary treatment of organic waste to effect at least 85 percent removal will be required. This treatment will be required even if Claytor Lake is not to be protected. The cost of this treatment alone is indicated in the following tabulation:

Years	Average Annual Cost (Million Dollars)	Capital Investment (Million Dollars)
1980-2000	1.2	13
2000-2020	1.7	19.4

Comparison of these figures with the cost of diversion plus secondary treatment indicates in effect that the cost of preserving Claytor Lake above the cost of waste treatment, which will be needed under minimum requirements in Section I is $1.3 million per year or an initial added investment of $18.2 million in the 20-year period from 1980 to 2000.

Value of Claytor Lake

The discussion of pollution in Section I has been thus far based upon the premise that Claytor Lake should be preserved. The monetary evaluation of this lake is difficult; however, the following figures may be of some value in establishing the worth of the impoundment. It should be noted that Claytor Lake State Park is "a water-oriented facility offering the best in boating, water skiing, fishing, and swimming" (Virginia's Commonwealth Supplement, 1965 - The Virginia Outdoor Recreation Study Commission Report, Vol. II).

To date, the State of Virginia has invested over $600,000 in facilities at Claytor Lake. In 1966, 266,324 persons visited Claytor

Lake State Park. Net revenue to the State of Virginia from the operation of Claytor Lake State Park between August 1, 1965, and July 30, 1966, was $41,750.

Plate 22 indicates the visitor-mileage relationship curve at Claytor Lake State Park in 1966. If the area under this curve is multiplied by an automobile operating cost of $0.017 per mile, per person value of approximately $470,000 per year is obtained. Assuming an average expenditure of $1.50 per person over the expenditure for automobile travel, a total expenditure for recreation at Claytor Lake State Park of approximately one million dollars per year is calculated.

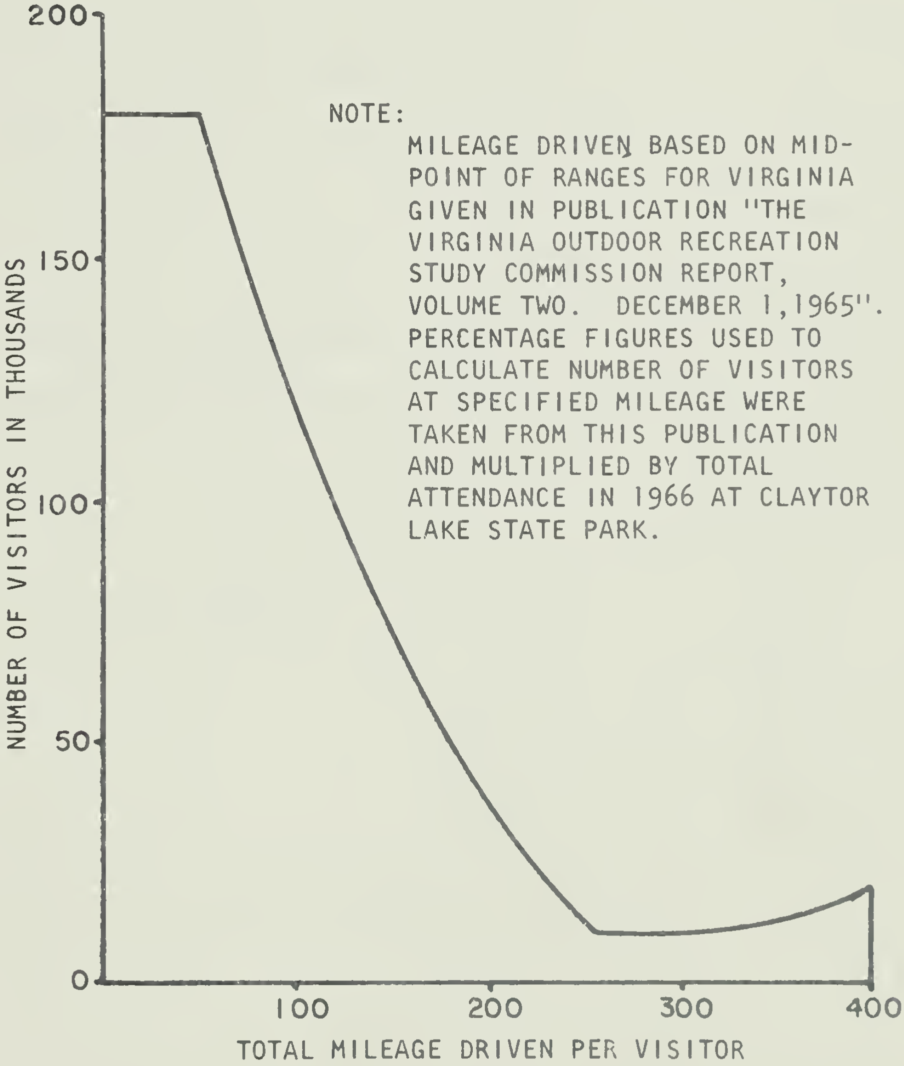
If the Lake becomes undesirable because of pollution, reduced visitation will undoubtedly result. The extent of this reduction is difficult to predict; however, it is felt that a 25-percent reduction would be a conservative assumption. A 25-percent reduction in expenditures attributable to recreation at Claytor Lake State Park would, therefore, be a loss of approximately one-quarter million dollars per year.

Another real loss which has not been estimated is the depreciation in the value of property adjacent to the Lake if the water quality becomes undesirable. The reluctance of various types of development to locate in the area because of the poor water quality is another factor of importance.

If the lake quality is degraded, increased water treatment costs to systems withdrawing water from the reservoir and, in all likelihood, to systems withdrawing water downstream from Claytor Dam will occur.

In summary, it can be stated that if Claytor Lake is permitted to degrade, an economic loss to the public as a whole, the State of Virginia, and citizens in the New River Basin will result. It

VISITOR-MILEAGE CURVE
1966
CLAYTOR LAKE STATE PARK



NOTE:

MILEAGE DRIVEN BASED ON MID-POINT OF RANGES FOR VIRGINIA GIVEN IN PUBLICATION "THE VIRGINIA OUTDOOR RECREATION STUDY COMMISSION REPORT, VOLUME TWO. DECEMBER 1,1965". PERCENTAGE FIGURES USED TO CALCULATE NUMBER OF VISITORS AT SPECIFIED MILEAGE WERE TAKEN FROM THIS PUBLICATION AND MULTIPLIED BY TOTAL ATTENDANCE IN 1966 AT CLAYTOR LAKE STATE PARK.

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also appears rather obvious that financial aid from the State of Virginia and/or Federal Government in addition to the expenditure of funds from the New River Basin will be necessary if damaging pollution of Claytor Lake is to be avoided.

It is a rare situation when people have an opportunity to prevent the deterioration of the water resource by timely action as opposed to the usual situation of attempting to improve water quality after damage has been done. This opportunity is present, however, in the New River Basin.

Public Water Supply - Section II

The following tabulation derived from projections contained in Volume IV lists the anticipated water needs for public supply in the lower section of New River.

Public Water Supply Demand - Section II

Year	Population	Demand-MGD
1970	49,500	6
1980	57,700	8
1990	77,000	12
2000	99,300	14
2010	107,250	20
2020	123,685	26

The water supply to meet the demand will come primarily from surface withdrawals, supplemented by ground-water supply. Presently, conventional treatment of surface-water withdrawal in the form of flocculation, coagulation, filtration, and chlorination provides potable water of excellent quality. With the projected magnitude of industrial development in the lower section and accompanying waste discharge, it is felt that a portion of the reach of New River below Claytor Dam and above Radford should be left free of waste discharges.

If waste from the upper section is diverted below Claytor Dam, it would, of course, be necessary to locate the water supply section above the point of waste discharge. The river flow in this reach under present and future flow conditions could provide large volumes of raw water necessary for public supply in the lower section. With the absence of waste effluents in the reach, conventional treatment would suffice to provide potable water.

A breakdown of the demand by major political subdivisions in the lower section is expected to approximate the following allocations. The figures shown are average daily demands, and demands 50 to 100 percent higher may be expected during periods of peak usage. It should also be pointed out that the demands by locality in Section II do not carry as high a level of confidence as the overall Basin demands. The locality demands do, however, provide a basis for long-range planning and alternative selection.

Public Water Supply Demand - Section II by Locality

	1980	2000	2020
Bland County	0.37	0.71	1.2
Craig County	0.05	0.09	0.17
Floyd County	0.4	1.1	2.1
Giles County	1.0	1.2	4.4
Montgomery County	3.0	4.8	8.2
Pulaski County	0.2	1.1	2.6
Tazewell County	1.2	1.5	2.0
Radford City	2.4	3.3	4.6

Note: All requirements in MGD. The above figures include service to residents in the confines of New River Basin only and do not include those living outside the Basin even though supplied by a waterworks system located in the Basin.

Availability of Water for Public Supply in Section II

The largest community in Bland County is the Town of Bland. Based on the recorded flows for Walker Creek at Bane, and adjusted for the Bland vicinity, the once-in-30-year 1-day low flow can easily provide water to year 2020 and beyond for the projected water demand. Ground-water yield is capable of satisfying between 10 and 20 percent of the demand.

The greater portion of Craig County lies in the James River Basin. Of that population of the County lying in the New River Basin, it can be expected that ground-water yield is sufficient to meet the demands to year 2020 and beyond.

The Town of Floyd is the largest community in Floyd County. Little River is the major tributary and has flows sufficient to meet the projected water demand to year 2020. Well production in Floyd County can be expected to satisfy between 10 and 20 percent of the water demand.

The main stem of New River divides Giles County into two approximately equal parts. The larger populated communities of the County (Narrows, Pearisburg) are located on New River, which is available for water supply. Additionally, tributary streams in the vicinity have adequate flows for consideration as raw water sources. Ground-water yield is satisfactory and can be expected to provide about 10 percent of the demand to year 2020 and beyond.

The populated areas of Montgomery County are Blacksburg and Christiansburg. The Blacksburg-Christiansburg-V.P.I. Water Authority is the main water supplier in the area. Raw water source is the New River below Radford. Based on past flow and anticipated future flow conditions, no problems are visualized through 2020 regarding necessary volumes of surface water to serve Montgomery County. However, it will be necessary to evaluate carefully future waste discharges in the area below Claytor Dam to assure an acceptable quality of raw water. It may be necessary in the future to relocate The Authority's intake. An alternative to this relocation would be the diversion of waste to a point downstream from the intake. It is estimated that ground-water yield may provide 10 percent of the water demand to year 2020.

Back Creek is the major tributary in that portion of Pulaski County that lies in the lower section. No problem is foreseen in providing the projected volumes of water to year 2020. Preliminary investigation indicates satisfactory ground-water yield which could meet at least 25 percent of the demand.

With the exception of the Bluefield area, most of Tazewell County lies in the Clinch River watershed tributary to the Tennessee River Basin. Bluefield, Virginia, at the present time, uses the Bluestone River as a raw water source. The capability of the Bluestone to provide larger quantities of water for future needs is severely limited. With an anticipated future public water need of greater than four MGD in the Bluefield, Virginia-West Virginia area, additional sources of supply will be required. One potential source for raw water is an impoundment on Mud Fork. Other water-related State and Federal agencies have reviewed this location for a water-quality purpose impoundment. It appears that this particular site might provide storage for both water quality and water supply with an additional water-quality impoundment located elsewhere on the Bluestone River watershed. Ground-water potential in the area is believed to be good and may be capable of meeting 25 to 50 percent of the projected water demand to year 2020 with favorable topography from well sites to point of distribution.

The City of Radford uses New River as a raw water source. Based on present and anticipated future flow conditions there are no foreseeable problems regarding adequate quantities of surface water. It may be necessary to restrict waste discharges to areas below the intake or relocate the intake to assure surface water of satisfactory quality for public supply. Ground-water potential in the Radford vicinity is good and capable of satisfying at least 10-15 percent of the projected demand to year 2020.

Cost Estimates of Public Water Supply in Section II

Listed in the following table are cost estimates to provide waterworks for the population served by public water during the 1980-2000 and 2000-2020 periods. The estimates are shown as annual average costs including operation and maintenance and initial investment cost. These figures include replacement costs for existing facilities. The costs shown are associated with surface water withdrawal and ground-water supply which may be used to supplement the water demand.

Cost Estimates for Public Water Supply - Section II

Period	Volume of Water MGD	Average Annual Cost (Million Dollars)	Capital Investment (Million Dollars)
1980-2000	14	1.2	13.0
2000-2020	26	1.4	15.5

Note: 20-year amortization period at 4½ percent interest.

Private Water Supply in Section II

The following tabulation lists the anticipated water demand for private supplies in the lower section of New River.

Private Demand

Year	Demand-MGD
1970	3.3
1980	3.8
1990	4.9
2000	6.0
2010	7.2
2020	9.4

Almost all of the private supply will come from springs and wells. Ground water is abundant in Section II, and there appear to be no foreseeable problems in either quality or quantity to satisfy the private supply demand. Cost estimates vary according to the size and type of installation and will be borne by the individual user.

Industrial Water Supply Demand in Section II

Listed below is the projected industrial water demand for the lower section of New River Basin.

Year	Demand-MGD
1970	106
1980	194
1990	216
2000	286
2010	308
2020	388

The exact location of industrial expansion in this section with respect to county location or proximity to the main stem of New River has not been forecast. Based on past and anticipated future flow conditions and availability of ground water, no problem is foreseen in meeting the projected demands to year 2020. With utilization of ground-water potential it is expected that approximately 10-15 percent of the demand to year 2020 can be satisfied by ground water.

Listed below are the cost estimates to provide the projected volume of treated water in the lower section.

Cost Estimates for Industrial Water Supply - Section II

Period	Volume of Water MGD	Average Annual Cost (Million Dollars)	Capital Investment (Million Dollars)
1980-2000	301	9.	105.
2000-2020	408	12.2	143.

Note: 20-year amortization period at 4½ percent interest.

Demand for Cooling Water

Tabulated below is the projected cooling water demand for thermal electric generation in the lower section. No additional cooling-water demand is anticipated in Section I.

Year	Demand-MGD
1970	400
1980	500
1990	1,300
2000	1,500

Assuming construction of the Blue Ridge Project and regulation to provide for 1,200 CFS release from Claytor Dam (once-in-30 year 1-day low flow frequency) sufficient volumes of water will be available to year 1990. This projection takes into account stream temperature standards as proposed by the Virginia State Water Control Board.

Biochemical Water Quality in Section II

As discussed in Volume IV, the generation of waste in New River Basin is expected to increase with increased industrial and domestic water demand. Tabulated below are the projected quantities of raw waste in pounds of 5-day BOD for the lower section of New River Basin.

Year	Chemical	Food	Textile	Pulp and Paper	Sanitary	TOTAL
1970	75,000	15,800	10,500	-	14,900	116,200
1980	127,500	21,000	15,800	31,700	17,300	213,300
1990	135,000	31,500	21,000	40,800	23,100	251,400
2000	180,000	31,500	26,200	49,000	25,900	312,600
2010	187,500	41,900	31,500	55,400	32,200	348,500
2020	225,000	47,300	36,700	66,500	38,800	414,300

Discussed earlier in this chapter was the possibility of diverting the waste loads from the upper section to the lower section of the main stem of the New River with the objective of slowing or reducing eutrophication of existing and proposed lakes in Section I. The projected quantities of waste diverted, assuming primary or secondary treatment, would not endanger significantly the predicted biochemical quality of the lower section of New River.

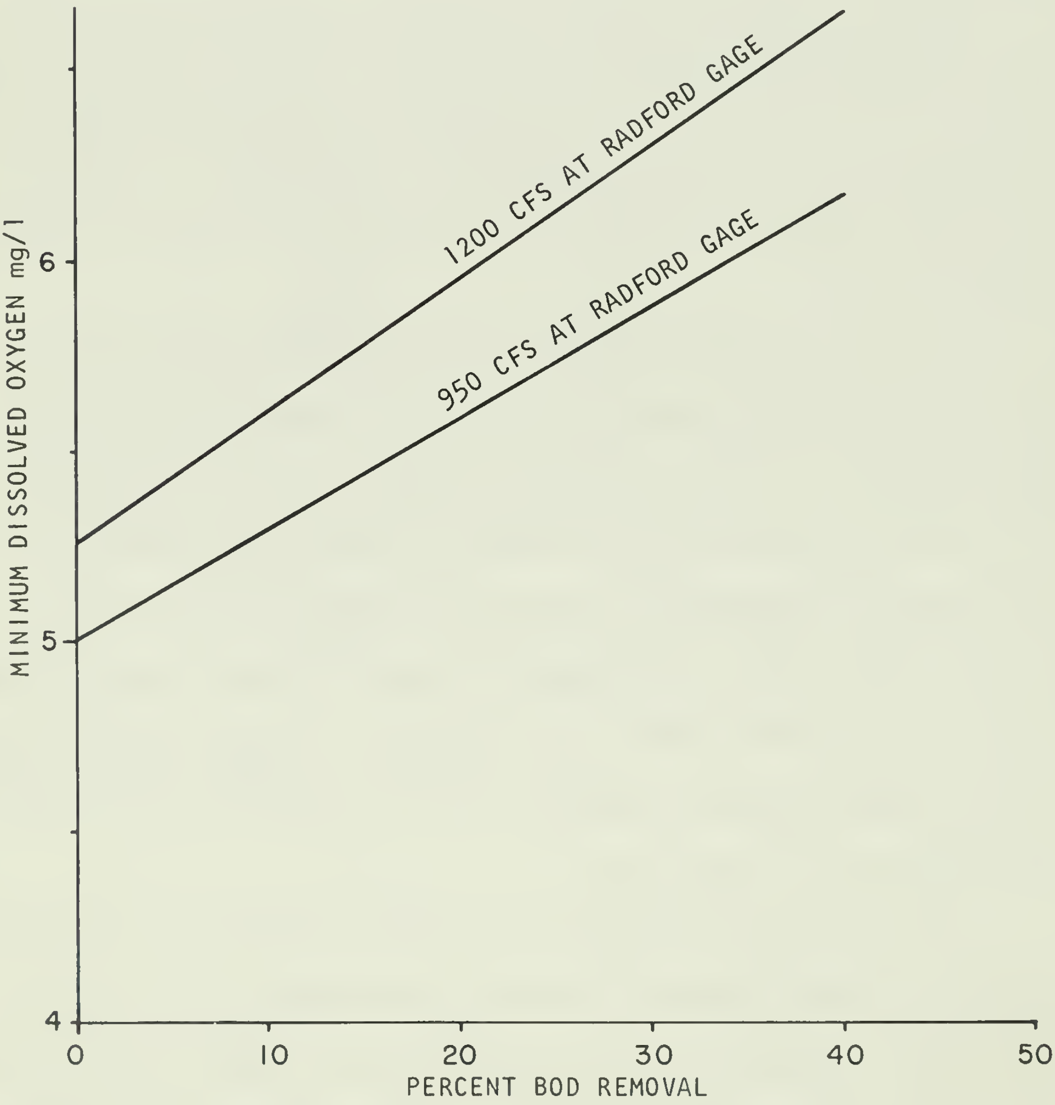
Shown on Plates 23 and 24 are minimum dissolved oxygen predictions based on flow versus percent BOD removal for the years 1980 and 2020. These graphs were derived from information presented in Volume IV of the New River Basin Study. The D.O. predictions assume no significant algal activity.

Briefly, the graphs indicate that with present and possible future flow regimes respectively of 950 and 1,200 CFS (once-in-10-year consecutive 7-day low flow) at Radford and with varying BOD removal efficiencies, various dissolved oxygen concentrations can be attained. A minimum D.O. concentration of 4 mg/l was used as a lower limit. This is in keeping with the proposed standards developed by the Virginia State Water Control Board. It should be noted that with increased treatment efficiency and/or increased flow, enhanced water quality will result.

Future waste discharges in most areas of Section II will eventually have to be made directly to the main stem of New River. Present indication is that most tributary streams receiving waste effluents have reached a level where increased volumes of waste discharges will degrade stream quality.

A major portion of Chapter IV, the biochemical water quality

MINIMUM DISSOLVED OXYGEN BETWEEN RADFORD AND VA. - W. VA. LINE-
PROJECTED 1980 WASTE LOADS



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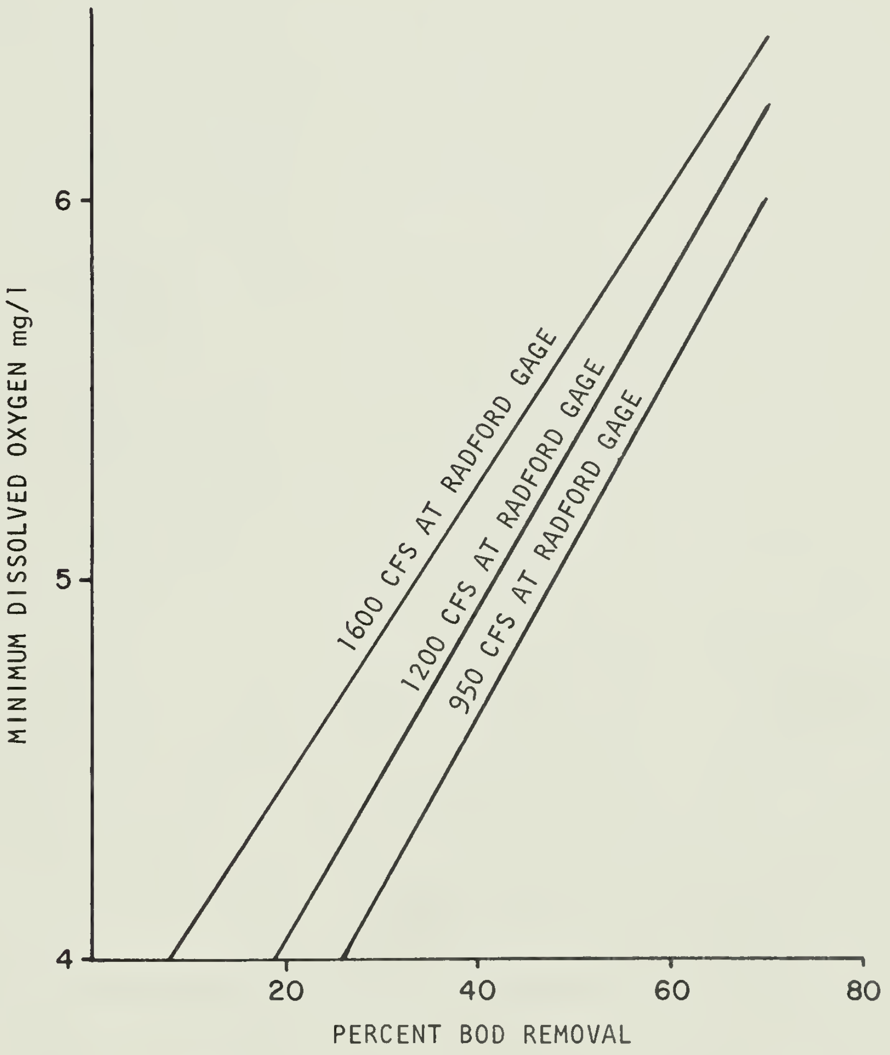
MINIMUM DISSOLVED OXYGEN BETWEEN
RADFORD AND VA. - W. VA. LINE-
PROJECTED 2020 WASTE LOADS



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section of Volume IV, indicated the effects of algal activity in the lower section of New River. With the projected magnitude of waste generation in this section, it will be necessary that nutrients, in the form of nitrogen and phosphorous compounds in waste effluents, be reduced to acceptable levels prior to discharge. Current research in the field of nutrient enrichment and subsequent effect on algal photosynthesis and respiration has not developed a consensus on what the optimum concentrations of nutrients are. However, it has been assumed that limiting concentrations of 2 mg/l and 1 mg/l of nitrogen and phosphorous respectively in the River will insure reasonably good water quality.

Table 3 contains estimates of possible nutrient loadings to the lower section of New River if there are no requirements established for nutrient removal. These estimates are based on a survey of reported concentrations of nutrients in waste effluents from sanitary and industrial discharges. Additionally, a flow of 1,045 CFS and existing concentrations of 1 mg/l N and 0.5 mg/l P were assumed to be present in New River below Claytor Reservoir. A flow of 1,045 CFS represents the existing once-in-10-year 7-day low flow average between Radford and Glen Lyn. It should be noted that actual nitrogen concentration in the stream now exceeds the 2 mg/l limit, primarily because of the inudstrial discharge at Radford Arsenal.

It can be seen that the projected nutrient concentrations in the River are in excess of the 2 mg/l N and 1 mg/l P even though the present loading from the Radford Arsenal is disregarded in the calculations. Further, it can be seen that over 90 percent of the total discharged nutrients are associated with the projected industrial

TABLE 3

PROJECTED DAILY NITROGEN AND PHOSPHOROUS LOADINGS FROM INDUSTRIAL AND SANITARY DISCHARGES IN NEW RIVER - SECTION II

Year	lbs. of Total N Industrial	lbs. of Total N Sanitary	lbs. of Soluble P Industrial	lbs. of Soluble P Sanitary	Total N * in River mg/l	Soluble P * in River mg/l
1980	32,600	2,880	16,300	1,440	7	4
1990	38,000	3,860	19,000	1,930	9	4
2000	47,800	4,320	23,900	2,160	10	5
2010	52,800	5,370	26,400	2,685	11	6
2020	62,500	6,460	31,250	3,230	13	7

* Assumes background concentration of 1 mg/l Total Nitrogen, and 0.5 mg/l of Soluble Phosphorous in River.

River Flow of 1045 CFS

N - Nitrogen

P - Phosphorous

discharge. The projections indicate that it will be necessary to reduce the nutrient concentrations in wastes to levels below that which induce algal proliferation, if it is desired to curtail or limit diurnal fluctuation of D.O. in the lower section of New River.

While the above projection of nutrient concentrations has been limited to nitrogen and phosphorous removal recommendations, future consideration of additional enrichment substances in waste should also be given consideration as circumstances dictate.

Listed below are cost estimates for providing waste treatment facilities of 35 and 85 percent BOD removal for sanitary and industrial wastes in the lower section of New River. The costs shown are in 1965 dollars with a 20-year amortization period at 4½ percent interest. The costs include replacement costs for existing facilities. No estimate of the cost of nutrient removal has been projected. Projections of industrial waste indicate that a large portion of nutrient additions will come from industry. In-plant reduction and waste volume reductions are important areas in the industrial waste problem. Since the degree of such reduction cannot be ascertained with reasonable certainty at this time, the costs of nutrient removal are not shown. Research in the field of advanced waste treatment seems to indicate that nutrient removal costs following secondary treatment will be approximately $0.15 per 1,000 gallons of waste treated. It is considered impractical, at best, and in all likelihood impossible to provide dilution flows by augmentation sufficient to prevent stream degradation by the influence of future nutrient concentrations.

Sanitary Waste Treatment - Section II

New River Basin - 35% BOD Removal

Period	Volume of Waste MGD	Average Annual Cost (Dollars)	Capital Investment (Dollars)
1980-2000	13	478,000	5,270,000
2000-2020	24	845,000	9,350,000

Note: Assumes 20-year amortization at 4½ percent interest.

Sanitary Waste Treatment - Section II

New River Basin - 85% BOD Removal

Period	Volume of Waste MGD	Average Annual Cost (Dollars)	Capital Investment (Dollars)
1980-2000	13	647,000	7,150,000
2000-2020	24	1,155,000	12,750,000

Note: Assumes 20-year amortization at 4½ percent interest.

Industrial Waste Treatment - Section II

New River Basin - 35% BOD Removal

Period	Volume of Waste MGD	Average Annual Cost (Dollars)	Capital Investment (Dollars)
1980-2000	247	5,180,000	57,200,000
2000-2020	336	7,050,000	78,000,000

Note: Assumes 20-year amortization at 4½ percent interest.

Industrial Waste Treatment - Section II

New River Basin - 85% BOD Removal

Period	Volume of Waste MGD	Average Annual Cost (Million Dollars)	Capital Investment (Million Dollars)
1980-2000	247	7.5	83
2000-2020	336	11.4	126

Note: Assumes 20-year amortization at 4½ percent interest

Engineering Alternatives for Water Supply and Waste Assimilation in Tributary Problem Areas - Section II

The problems associated with future waste discharges in tributary streams in Section II will probably limit themselves to three streams - Crab Creek, Stroubles Creek, and the Bluestone River. It appears impractical to impound waters for flow augmentation in Crab Creek and Stroubles Creek. The problems of waste pollution in these tributaries would, therefore, seem to resolve into two solutions: diversion of the waste to larger streams or tertiary treatment requiring removal of the majority of pollutants from the waste effluents.

Although tertiary treatment for small flows may be practical, it is believed that the most economical long-range solution to pollution problems on Crab Creek and Stroubles Creek rests with diversion of the wastes entering these streams to the main stem of the New River in Section II.

The Bluefield, Virginia-West Virginia area and its effect on the Bluestone River poses the most difficult single problem of pollution in the entire New River Basin in Virginia.

Examination of two tributaries to the Bluestone River - Brush Fork and Mud Fork - indicates the possibility of constructing reservoirs on each stream. A practical limit of approximately 21,400 acre-feet of water supply and water quality storage is indicated in the two reservoirs. Assuming drawdowns of 25 feet in the 90-day critical low-flow period, 12,500 acre-feet of water would be available for meeting the projected water supply and water quality needs of the Bluefield area until 1995. This assumes that a high degree of secondary treatment will be practiced on all waste in the

Bluefield area. It is further assumed that either water will be diverted from the reservoir to the critical stretch or that waste will be diverted to an area near the confluence of Bluestone River and Brush Fork or Mud Fork. The reservoir drawdown under this scheme will not provide lakes having the capacity to supply high-grade recreation. The benefits of the augmentation water will, however, be felt in the immediate area and should result in an improved Bluestone River, suitable for recreation.

A second alternative solution to water-supply and waste-pollution problems in the area would be the development of small impoundments for only water supply and the attainment of virtually complete removal of BOD, nitrogen, and phosphorous from all waste effluent.

The following tabulation shows costs for developing a reservoir on Mud Fork and a reservoir on Brush Fork, costs for a high degree of secondary treatment, and costs for piping dilution water to the point of need. All values are in terms of 1966 dollars and are based upon debt repayment in 20 years at 4½ percent interest with normal operation and maintenance figures. An average future water demand of 4.5 MGD is assumed in the Bluefield, Virginia-West Virginia sector.

	Average Annual Cost (Dollars)	Capital Investment (Dollars)
Impoundment Cost	314,000	4,000,000
Waste treatment and Dilution water Diversion	271,000	2,800,000

It should be pointed out that the costs shown are preliminary in nature and do not reflect detailed engineering study and site evaluation. The costs do, however, show the magnitude involved and the order of comparison.

Estimated costs for a single purpose reservoir to supply public and industrial water demand and costs for advanced waste treatment assuming virtually complete removal of BOD and nutrients are as follow:

	Average Annual Cost (Dollars)	Capital Investment (Dollars)
Water Supply Impoundment Costs	68,000	750,000
Waste Treatment Costs	472,000	4,900,000

Analyses of the preceeding two tables indicate that there is a slight advantage for the advanced waste treatment and single purpose reservoir scheme over the flow augmentation-secondary treatment plan. The costs are practically the same and in light of the uncertainty in predicting costs for advanced waste treatment, it appears that the more conventional scheme of normal secondary treatment and flow augmentation might be preferable.

The initial investment shown under either alternative is very large and without considerable State and/or Federal aid could probably not be financed by the Bluefield area itself. The magnitude of the figures does point up the need for area-wide cooperation in both the Virginia and West Virginia sectors if the common problems of water supply and pollution control are to be solved.

Irrigation. The water supply for agricultural irrigation in the Basin will be, with few exceptions, from surface waters. The adequecy of the supply during periods of drought should be ascertained with respect to low flow, drainage area, and runoff. Volumes I, III, and IV of the New River Study contain information pertinent to low flow, drainage, runoff, evapotranspiration, and drought frequency that will aid in establishing the volume of water needed for irrigation and the dependability of the supply for the individual user.

The projected once-in-10-year drought-water requirements for irrigation that would maintain soil moisture in the 2-inch level of the root zone and based upon the median projections for acres irrigated are given in the following table:

County	1980*	2000*	2020*
Bland	.2	.7	1.8
Carroll	.3	.7	1.8
Craig	.08	.2	.5
Floyd	.2	.6	1.6
Giles	.1	.3	.8
Grayson	.05	.1	.4
Montgomery	.7	1.8	4.2
Pulaski	.2	.6	1.3
Smyth	.07	.2	.3
Tazewell	.03	.09	.2
Wythe	.7	1.7	4.5

* - MGD during growing season, April-September

Cost Estimates of Irrigation. The capital investment is the expenditure for establishing a source of water and purchasing a distribution system. The annual cost estimates include depreciation, interest, insurance, taxes, repairs, gas, oil, and labor.

It has been assumed that the water supply will be from farm ponds and that investment cost will be $100 per acre-foot of storage exclusive of land cost. Water supplies from wells or flowing streams would have different cost considerations.

The distribution system that is used in this cost estimate is the sprinkler type and consists of approximately 1,200 feet of 3-inch pipe, and it has been assumed that the water supply is within 500-600 feet of the fields to be irrigated and that the difference in elevation is not over 50 feet. It has also been assumed that each unit will be used to irrigate 10 acres of land. The estimated cost of the above described system is about $2,200 for distribution equipment and $900 for the water supply. The following Basin estimates are based on 1966 averages and are not detailed final figures:

Years	Average Annual Cost (Million Dollars)	Capital Investment (Million Dollars)
1980-2000	.2	.9
2000-2020	.4	2.2

Livestock Water Requirements

Volume IV of the Comprehensive New River Basin Plan contains the estimated future livestock water requirements. The following table lists these quantities:

Year	Demand-MGD
1980	3.3
2000	3.6
2020	4.0

An abundance of water is available in the Basin to meet the livestock needs. Ground water or surface water will be used depending upon particular situations. As is the case with private demand, costs will vary according to the size and type of installation. These costs will be borne by the individual user.

Ground-Water Development Alternatives

The availability of ground-water development alternatives is important in the matching of specific demands to a feasible supply. The purpose of this section is a description of selected sites in the New River Basin where ground water is available in estimated or in partially proven quantity and quality. Sites are selected on the basis of ground-water considerations without respect to ownership or to transportation, industrial, or other development.

The general geohydrology and hydrogeology of the Basin have been discussed in Chapter V of Volume III and the distribution, lithology, and hydrology of the formations have been described. With respect to these characteristics the aquifers of the Blue Ridge and of the Valley and Ridge physiographic provinces are respectively unique, and those of the Cumberland Plateau physiographic province are not considered significant within the scope of this report.

It is to be borne in mind that a stream basin of whatever size has a water-budget that is naturally balanced, the input factor being precipitation and the output factor being evaporation and runoff. Surface-stream flow or runoff and subsurface flow or seepage, represent the partially measurable water yield of a basin which is susceptible to some degree of development. Such yield may be stated as a dependable average volume at any point on a basin's surface drainage system and at the same point as an estimated flow or seepage through the underlying cross-section of aquifers which transmit subsurface outflow. In most basins there are both surface and underground drainage components which together equal the water yield.

The ground-water yield of a basin is a gross conception, and it may not be important at sites of individual wells nor at areas of a well field. There is a distinct possibility in small basins that heavy pumpage might reduce runoff along substantial reaches of a small stream; therefore, taking supply directly from such a stream might be preferable to pumping it from a well.

As set forth in Volume III, there are certain general geological and hydrological conditions which favor the collection, storage, transmission and pumping of ground water and a few sites were indicated at which such conditions prevail. A selection of some of the more apparent localities is listed in Table 4.

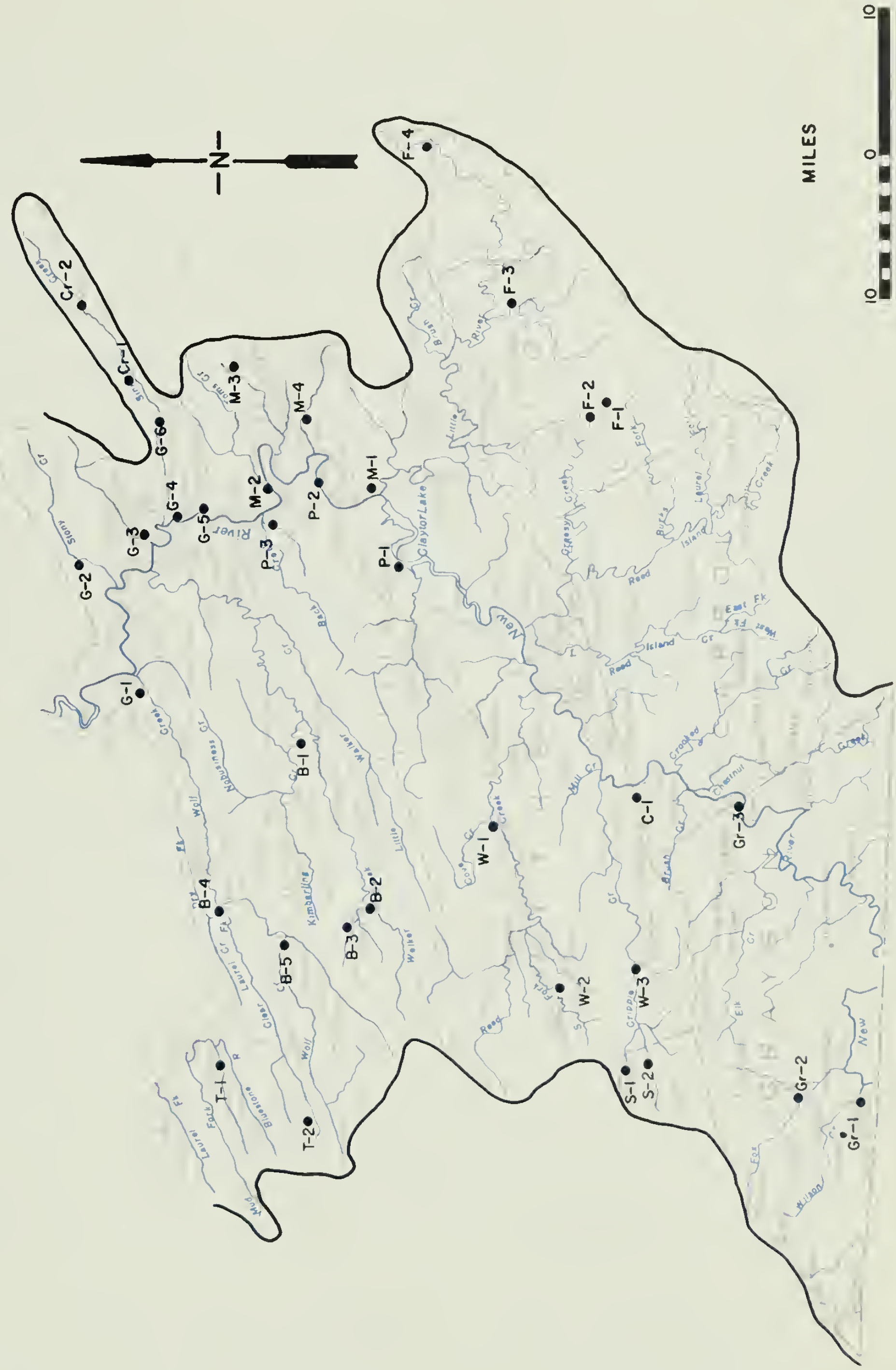
In Table 4, Selected Well Fields, the sites described are named in Column 2 and given numbers in Column 1 by counties. The numbers are keyed to a basin map, Plate 25. It is to be noted that locations of development alternatives are indicated by "areas", "vicinities" or "valleys". While field observations have been made at some of these places, the criteria used in estimating their respective potential productions are usually theoretical, and the estimated productions, therefore, include considerable latitude. It is understood that actual production from any aquifer or set of aquifers never is known until properly located and designed wells have been constructed and thorough pumping tests conducted.

Column 3, Formations, indicates the formation occurring at the surface at the sites described. At varying distances below the surface normally associated formations might be encountered by drilling, and faulting at other places might introduce a varying sequence. Formation names are those used on the Geologic Map of Virginia, 1963.

Potential yield per well in gallons per minute, Column 4, is listed in round figures which indicate magnitude rather than specific volume.

In Column 5 there is listed the probable yield of a well field in gallons per minute which is a multiple of the number of wells listed in Column 6. The number of wells listed in Column 6 is an estimate of the size of a well field which the area named might accommodate. This number, of course, is subject to revision upon more careful study of the respective sites; however, they are intended to indicate an estimated size of a possible well field at the respective

SELECTED WELL FIELDS
NEW RIVER BASIN IN VIRGINIA



DIVISION OF WATER RESOURCES	SC.	DATE 10-3-67	SHT. 1	OF 1
DE.	DR. C.R.B.	APP.	REV.	NO.

PLATE NO. 25

Table 4

SELECTED WELL FIELDS
New River Basin

Site No. (Plata 25) (1)	Site (2)	Formation* (3)	Per Wall, GPM Potential Yield (4)	Well Field, GPM Potential Yield (5)	Based On Wells In Field (6)	Range of Well Depths, Feet (7)	Range of Well Diameters, Inches (8)
Bland County							
B-1	Intarsection of Roads 42 and 606	Omuu Su	75-150	150-300	2	250-800	6
B-2	Confluence of Town and Bland Creeks, Bland	Ɛer	75-150	150-300	2	250-800	6
B-3	Between Town and Crab Orchard Creeks, 0.5 mi. Wast of Bland	Ɛhk Saltville Bland Fault Southside	75-150	150-300	2	250-800	6
B-4	Rocky Gap along Wolf Creek	Olmu Ɛcr Narrows Fault	75-200	150-400	2	200-800	6
B-5	Bastian, near confluence of Wolf and Hunting Camp Creeks	Olmu Su	75-200	225-600	3	200-800	6
Carroll County							
C-1	Raketown	Ɛe	100-500	400-2000	4	200-800	6-8
Craig County							
Cr-1	1 Mi S W of Huffman along Sinking Craek	Oku Ɛcr	75-200	225-600	3	150-700	6
Cr-2	Valley of Sinking Creek between Farrier and Gravel Hill Branches	Oku Ɛcr	75-150	300-600	4	150-700	6
Floyd County							
F-1 F-2	0.5 and 1.5 Mi N. of Willis	pƐly	75-100	150-200	2	100-300	6
F-3	On West Fork along Road 698 0.6 Mi North of Road 8	pƐly	75-100	150-200	2	100-300	6
F-4	Check, along Meadow Run	pƐly	75-100	150-200	2	100-300	6
Giles County							
G-1	Valley of Wolf Creek above Narrows	Ɛcr	100-400	500-2000	5	150-800	6-8
G-2	Valley of Stony Creek, Kimballton to Olean	Omuu Narrows Fault	100-400	500-2000	5	200-800	6-8
G-3	Valley of Little Stony Creek, Pembroke	Oku	200-900	1200-5400	6	200-900	6-10
G-4	Goodwins Ferry	Omuu Saltville-Bland Fault System	100-	-	Restricted Area	200-700	6-
G-5	Eggleston, Road 691	Oku	300-1000	1200-4000	4	250-900	6-10
G-6	Newport 1 Mi. N E. Road 42	Omuu	100-400	400-1600	4	200-800	6-8
G-7	Poplar Hill	Omuu	100-400	300-1200	3	200-800	6-8
G-8	Staffordsville	Oku Ɛcr	100-400	200-800	2	200-800	6-8
G-9	Bane, 1 Mi. E on Road 633	Ɛhk Ɛcr	200-800	1000-4000	5	200-800	6-10
Grayson County							
Gr-1	Mouth of Wilson	grgn	50-100	100-200	2	100-300	6
Gr-2	Confluence of Fox and Middle Fox Creeks	grgn	50-100	100-200	2	100-300	6
Gr-3	Fries	Ɛch	100-200	100-200	2	100-400	6
Montgomery County							
M-1	N. of Interstate 81 and E. of New River	Ob Ɛe	100-800	400-3200	4	150-800	6-10
M-2	Whitethorne, Valley of Toms Creek	Pulaski Fault Ɛr	100-500	400-2000	4	150-700	6-8
M-3	Stroubles Creek Blacksburg vicinity	Ɛe Ɛr	75-500	300-2000	4	200-700	6-8
M-4	Vicker, along Crab Creek	Ɛe Ɛr Pulaski Fault	75-300	225-900	3	200-700	6-8
Pulaski County							
P-1	Between Newbern and Claytor Lake along Pulaski Fault to Crossing of New River	Ɛe	100-400	500-2000	5	200-600	6-8
P-2	New River Depot E. to New River along Pulaski Fault	Ɛe	100-400	400-1600	4	200-600	6-8
P-3	Belspring Vicinity	Ɛe	100-400	800-3200	8	150-600	6-8
Smyth County							
S-1	Cedar Springs	Ɛs	100-400	300-1200	3	150-600	6-8
S-2	Valley of Blue Spring Creek	Ɛs Ɛr	100-400	300-1200	3	150-600	6-8
Tazewell County							
T-1	St. Clair to Dill Spring Vicinity	Ɛhk Ɛcr Oku Omuu	100-400	600-1600	4	150-600	6-8
T-2	Shawver Mill Valley of Clear Creek	Ɛcr Oku Omuu	75-300	150-600	2	150-500	6-8
Wythe County							
W-1	Max Meadows	Ɛe	100-300	300-900	3	150-500	6-8
W-2	Crockett, Road 625 at S. Fork Reed Creek	Ɛe	75-250	225-750	3	150-500	6
W-3	Speedwell to Cedar Springs along Cripple Creek	Ɛs	100-400	400-1600	4	150-500	6-8

*See Excerpt, Geologic Map of Virginia, 1963, New River Basin, Volume III - Hydrologic Analysis, Planning Bulletin 203, July 1967.

localities.

Column 7 contains a list of the range in depths per well at the respective sites, and these depths represent estimates because no detailed study has been made of well sites, and very few wells are available from which to collect such information. Depths do not vary greatly from one locality to another.

In Column 8, Range of Diameters, Inches, there are listed diameters of wells or the finished inside diameter of wells at the pump settings. Diameters at which a well hole might be started or to which the hole might be reamed at various portions of its length depend upon the conditions of construction and the volume of water to be pumped.

Where confidence in the probable amount of water that will be produced from a hole is not sufficient to warrant starting a hole at a fairly large diameter, it usually is desirable to drill an exploration hole of a fairly small diameter which can be reamed to the required diameter after the supply that is found is at least partially proved to be of a certain magnitude. If pumping and drawdown in a small diameter exploration hole indicate a large supply to a well, then the hole can be reamed to a diameter that will accommodate a pipe into which a pump can be installed to produce the volume indicated.

Ground-Water Production Costs and Data

Construction of water wells is not stereotyped and each well construction job is unique even though more-or-less standard well construction specifications might be used. Most wells designed to supply industry and municipalities in the New River Basin will be constructed in hard carbonate rock. Unless a small-diameter exploration or pilot hole is drilled first, a hole is started at a diameter of about 22 inches, and this diameter is maintained to the maximum depth of grouting. At or below the bottom of grouting the diameter of drilling is reduced in one or more steps to about 12 inches, and under some drilling conditions a second reduction might be necessary. Reaming to diameters greater than those of the drilled hole is employed under some conditions to meet specifications for producing a potential or proved volume.

Selecting the site of a well or of a well field, and the designing of a well involves location of a potential volume desired by use of geohydrologic criteria and sufficient description of existing conditions to enable designing of a well and formulating construction specifications. Development of a successful supply requires the coordinated services of a geohydrologist, an engineer to design and produce specifications for a well, and a well construction contractor with adequate equipment and skilled well drillers. Although detailed discussion of such services in their many ramifications are outside the scope of this report, certain basic data for industrial or municipal wells are provided below.

General data for a "rock well" in limestone or dolomite:

Volume of yield required: 800 GPM

Drilling diameter	
22-inch, surface to about 100 feet	$15 - $20/foot
12-inch, from 100-foot depth to bottom	$15 - $20/foot
Depth	
250-750 feet total	$3,750-$15,000

Well Pipe (thin)

20-inch	$9.50/foot
16-inch	$8.50/foot
12-inch	$6.50/foot

Drive Shoe

20-inch	$275. each
16-inch	$175. each
12-inch	$100. each

Assume

Static level, below surface	60-150 feet
Pumping level	100-200 feet
Pump setting	140-240 feet
Developing and test-pumping	$25. hour

Pump

Turbine with motor, controls, housing; ready for service	250 GPM	$8,000
	750 GPM	$10,000

Gross Well Cost	$15,000-$18,000
Per 1,000 gallons of production Estimate includes minor storage, depreciation, replacement, taxes, power and personnel costs.	$0.06-$0.12

Conjunctive Use. In considering the development of water resources for application to a particular need, conjunctive use of surface water and ground water is worthy of consideration in meeting some requirements. While requirements vary widely in demand with respect to quality and quantity, these attributes, along with cost and availability of supply from the two sources, when used conjunctively might result in a more satisfactory and economic arrangement than if either source were used singly. With respect to volume of supply, surface sources yield far more water than ground sources at any one point. However, neither is unlimited, and the limits of volume must be determined before development is undertaken. Ground-water reservoirs are susceptible to overpumping, and exhaustive testing is necessary at the time of development to determine the sustained yield of a well or of a well field. Calculations should include a margin of safety including allowance for fluctuation of ground-water supply which results from seasonal and weather variations in precipitation.

As for quality, that of each source of supply is to be determined along with its seasonal fluctuations. At times of low runoff, water in streams contains a higher concentration of dissolved solids, although suspended materials may be low. Due to freshets and floods, the overall quality of surface water may change rapidly and frequently through a period of time during which that of ground water might not change significantly.

With respect to temperature, that of ground water probably will vary six or seven degrees during one year; whereas, surface water in the New River Basin might vary in temperature almost 50 degrees. Aside from the use of water for cooling, for which purpose treatment is not required for water from either source, ground water usually requires less treatment for application to any process than does surface water. Treatment of well water for the removal of hardness, as well as iron and manganese would be necessary in some localities.

Conjunctive use, therefore, can be advantageous in the development of many systems of water supply for industries. A simple example is the case of a demand in which untreated or partially treated water is required in relatively large volume for an industrial process and a much smaller volume is required for domestic and laboratory purposes.

Artificial Recharge and Storage. The feasibility of artificial recharge and storage of water in aquifers may influence the selection of a ground-water supply. Theoretically, it seems possible to induce recharge or replenishment of water into aquifers under certain conditions. Where this is possible, there is the distinct advantage of having water of lower temperature and, in most cases, of a high level of purity. Low temperature may be obtained by recharging during winter months when surface supply is cold and clear and abundant as well.

Generally, a system of aquifers will contain water at levels which are in "hydraulic balance" for the basin except where they are pumped heavily or recharged heavily. Since a certain balance exists with gradient inducing runoff, water recharged into aquifers in formations and structures typical of those in the New River Basin will drain out of the aquifers into the surface system after the natural levels or gradients are reached. In other words, water cannot be "piled up" or mounded in limestone aquifers. On the other hand, when an aquifer is pumped heavily, it is recharged quickly under the natural conditions usually existing in the New River Basin where there is a continuous relation between surface water and ground water at the places of greater ground-water potential.

It appears, then, that a scheme for artificially recharging aquifers in the New River Basin must be very exacting with the respect to time and volume removed and recharged.

It is well known that there are numerous caverns in the New River Basin, large portions of which are dry, and the question occurs as to whether or not they are suitable for storing water. To return to reasoning set forth above and realizing that these caverns have what might be considered inlets and outlets and that they usually contain water in their lower elevations, it might be concluded that if recharge were from a high elevation and that if discharge openings also were at relatively high elevations, then the caverns might contain large volumes of water.

Stream Flow Augmentation by Ground-Water Pumpage. An extension of the reasoning applied to recharge of ground-water reservoirs might be used in considering the possibility of augmentation of the low flow of streams. Further, it may be borne in mind that the water production of the small or large basin, by ground and surface runoff, is a certain volume under certain conditions. Augmentation of that runoff, therefore, would appear possible during short periods, at least. Locally there may occur a channel between a streambed and a ground-water reservoir. While this is not always the case, it theoretically can occur to the extent that pumps used in augmentation would merely circulate the water production of a given basin. Such a situation would not occur along a major stream because the volume of pumpage could not be a significant proportion of even the low flow of such streams, and the engineering and economic feasibility of such an undertaking is improbable. Even along small streams, the same conditions apply proportionately. A careful search might reveal a situation in which ground water could be pumped from one basin into another and thereby produce enough water to effectively augment natural low flow during a limited period of time. This might be expensive beyond justifications, and it might involve legal complications.

Although there is no known precedent in the augmentation of stream flow by pumpage of ground water in the New River Basin of

Virginia, the door should not be closed upon such a possibility. The many factors involved might be found in one system and in such a combination as to make the possibility a feasible reality.

CHAPTER III

HYDROELECTRIC POWER

General

The successful completion of a reservoir project containing hydroelectric power is dependent upon the suitability of the river, economical development of its water for power production, and the successful marketing of the electrical power output. A significant portion of future power needs will be met by construction of the proposed Appalachian Power Company Blue Ridge Project. This project, if constructed, will generate electrical power using the pumped storage concept. The project would consist of an upper reservoir and power plant having six 150,000 kilowatt generators and a lower reservoir project with two 25,000 kilowatt generators. Total dependable capacity would, therefore, be 950,000 kilowatts. The Blue Ridge Project would have multipurpose benefits of power production, water quality storage, flood control, and recreation. An analysis of the various benefits in the Blue Ridge development is contained in Chapter V of this Volume.

Preliminary study of the New River Basin in Volume IV of the Comprehensive Plan established the need for further investigation of additional potential power projects to meet future power requirements. An examination of the power market and the alternative means for supplying it established a value for potential power requirements. A study of certain projects which could aid in meeting these requirements is reported in this chapter. A brief explanation of various assumptions used in the project studies follows:

Stream Flow. Stream flow data for New River Basin Study was obtained from the publications of the United States Department of the Interior Geological Survey "Surface Water Records of Virginia", for the available years of record. For maximum power benefits received from surface runoff, the minimum and average flow for several years of stream record was analyzed. Average annual power output of a project was based on graphic analysis of the mass curve of flows recorded during the several years of consecutive minimum flows. At the present time, no effort is made to develop the detailed operating schedules, etc., for the potential projects.

Water Losses. Consideration was given for the losses through evaporation. For design purposes, approximately 34 inches per year of evaporation in the New River Basin area is considered adequate. However, for this study it was assumed that evaporation losses are balanced by the precipitation, thus gains and losses of flow from rainfall and evaporation are assumed to be equal and compensatory. Other losses considered were seepage, leakage, and no load operation.

Operating Head. The average head of a project was determined by considering the amount of flow, geology of the area, and the cost of the dam. Economy was the main item considered in selecting the height of the dam.

Head Loss. Wherever the powerhouse was located at the downstream base, head losses due to friction were considered to be one to two feet.

Efficiency. For preliminary estimates in calculating capacity and power output, the combined efficiency of transformer, generator, and turbine was assumed as 85 percent.

Installed Capacity. Turbine capacity was considered to provide maximum output at minimum head corresponding to maximum demand on the power plant. Generator capacity was provided for output at the best efficiency corresponding to the turbine output at average head.

Economic Analysis. Physical features of a project such as dam height, reservoir limits, etc., were established following a study of United States Geological Survey topographic maps, and the project cost was estimated based on the above physical features of the project. The costs shown are considered preliminary and are not detailed construction costs. Power benefits were considered to be the primary item for selection of a project for further study.

Load Factor. Annual generation was based on 12-15 percent load factor.

Annual Power Benefits. Annual power benefits from a hydroelectric plant were considered equal to those from a steam-electric plant of the same capacity in the same area. Annual generation was considered at the low tension bus.

Reservoir Development

The following projects were considered and omitted from the further study because of economic or other reasons:

(A)	Wolf Creek	Giles County
(B)	Sinking Creek	Giles County
(C)	Peak Creek	Pulaski County
(D)	Little Reed Island Creek	Pulaski County
(E)	Reed Creek	Wythe County
(F)	Cripple Creek	Wythe County
(G)	Crooked Creek	Carroll County
(H)	Elk Creek	Grayson County
(I)	Little River	Grayson County
(J)	New River (near Lone Ash)	Wythe County (Pumped Storage)
(K)	New River (near Riverside)	Grayson County.

Although the above projects were eliminated from study in as far as potential power development is considered, it should not be inferred that the projects could not be developed for specific purposes other than power generation.

Following are the projects that were included after careful evaluation of all the potential projects:

(1) Big Reed Island Creek (Pumped Storage)
(2) Walker Creek (Pumped Storage)
(3) Walker Creek (Conventional)
(4) Big Reed Island Creek (Conventional)
(5) Little River.

Attempt is made to discuss all the above projects briefly regarding their physical location, cost, etc. No effort is made, at this time, to prepare detailed estimates of the projects, reservoir regulation, etc. Project costs were calculated on unit cost basis. It should again be emphasized that the projects shown are potential projects with major emphasis on hydroelectric power generation. Plate 26 shows the location of all projects considered in this study.

Big Reed Island Creek Pumped Storage

Area Characteristics. The dam for Big Reed Island Creek is proposed approximately 2.0 miles from the confluence of Big Reed Island Creek and New River near Allisonia. The proposed dam site would be accessible by a secondary road from Allisonia and Boom Furnace. The dam and reservoir site is on limestone, and topography of the area is dominated by steep hills with vegetation cover. Most portions of Big Reed Island Creek are confined in gorge-like topography. If this project is considered for construction, a detailed geological investigation of the dam site area for foundation conditions should be undertaken. It appears from the preliminary investigation that construction material is available in the vicinity. Approximately one mile of U. S. 221, which crosses Big Reed Island Creek near New Hope, would require relocation. There are approximately 20 miles of improved and unimproved highways which would be relocated. There are no major railroads requiring relocation in the project. The reservoir woule be situated in Pulaski and Carroll Counties.

Physical Features of the Project. Big Reed Island Creek development is a pumped storage project. It consists of an upper dam on Big Reed Island Creek and a lower dam which will be modified, Claytor Dam. A profile of Big Reed Island Creek is shown in Plate 27.

Upper Project. Big Reed Island Creek Dam (upper dam) would be constructed across Big Reed Island Creek in Pulaski County. The top of the upper dam would be at elevation 2,220 feet. Approximate dam height is 318 feet.

Rock-filled clay core dikes are suggested on each side of the main structure. The total storage capacity of the Big Reed Island Creek reservoir at an elevation of 2,218 mean sea level would be approximately 750,000 acre-feet. Area-capacity relationships are shown on Plate 28.

Lower Project. The lower dam for the Big Reed Island Creek project is a raised Claytor Dam. It is estimated that Claytor Lake's capacity of approximately 244,000 acre-feet at elevation of 1,850 feet would be increased to approximately 400,000 acre-feet at an elevation of 1,890 feet above mean sea level. Increased storage will be available for discharge back to Big Reed Island Creek for reuse. The modified Claytor Dam will increase the existing capacity of the reservoir by approximately thirty percent and, thus, enlarge firm electrical capacity and annual output. The above estimate of

POTENTIAL HYDROELECTRIC DEVELOPMENT SITES
NEW RIVER BASIN

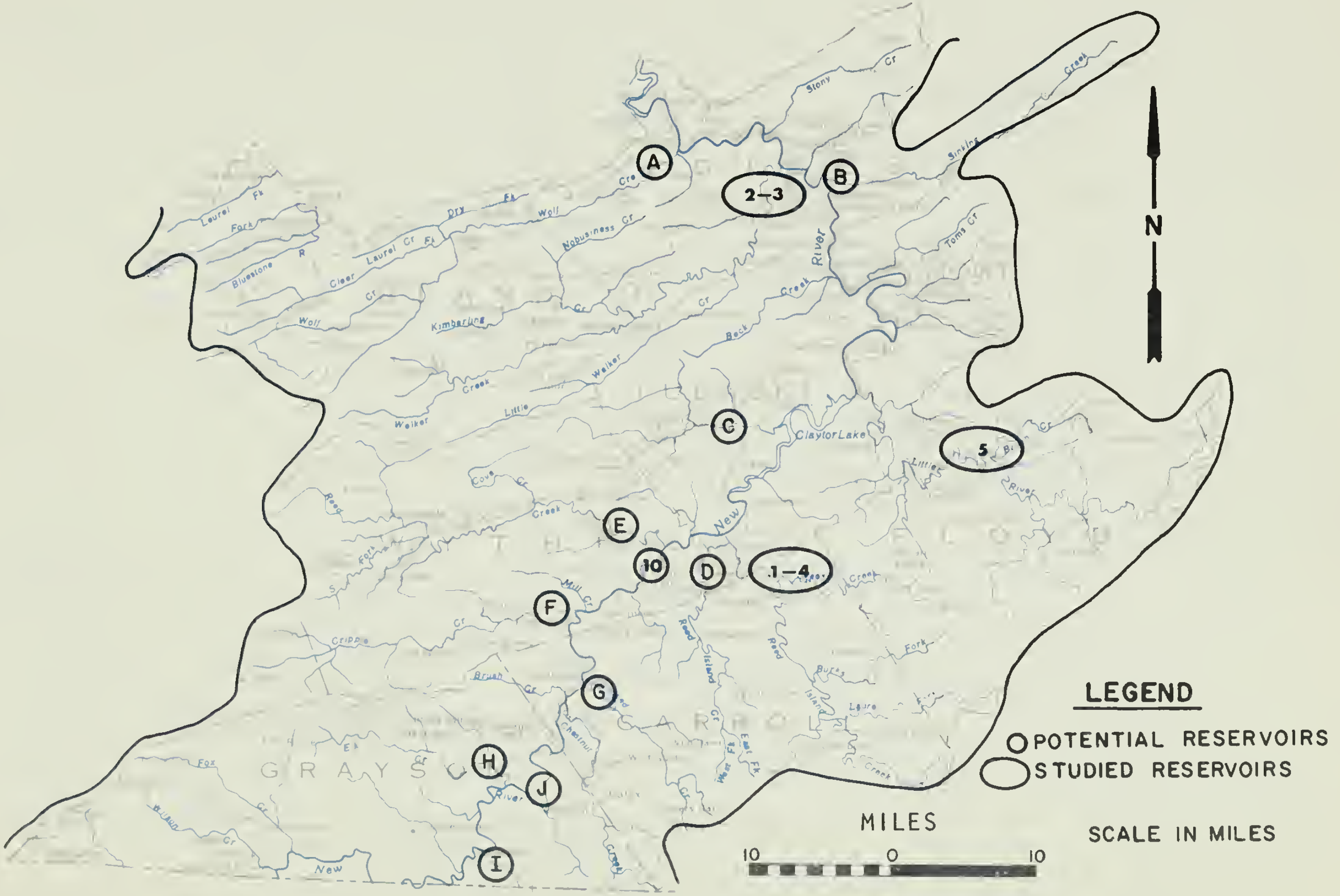


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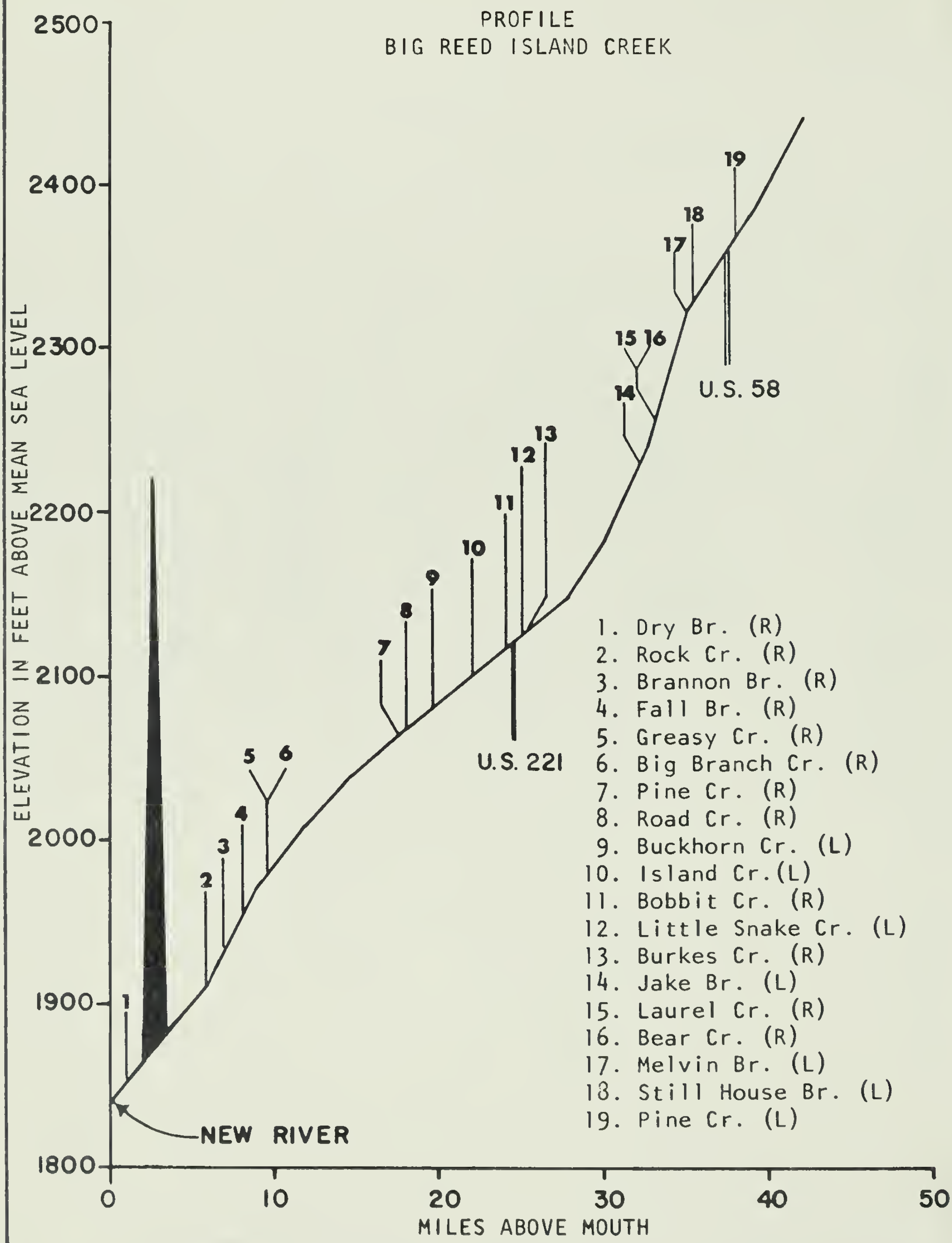
PLATE NO. 26



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BIG REED ISLAND CREEK PROFILE - N.R.B.	DE.	DR. M.N.F.	APP.	REV.	NO.

PLATE NO. 27

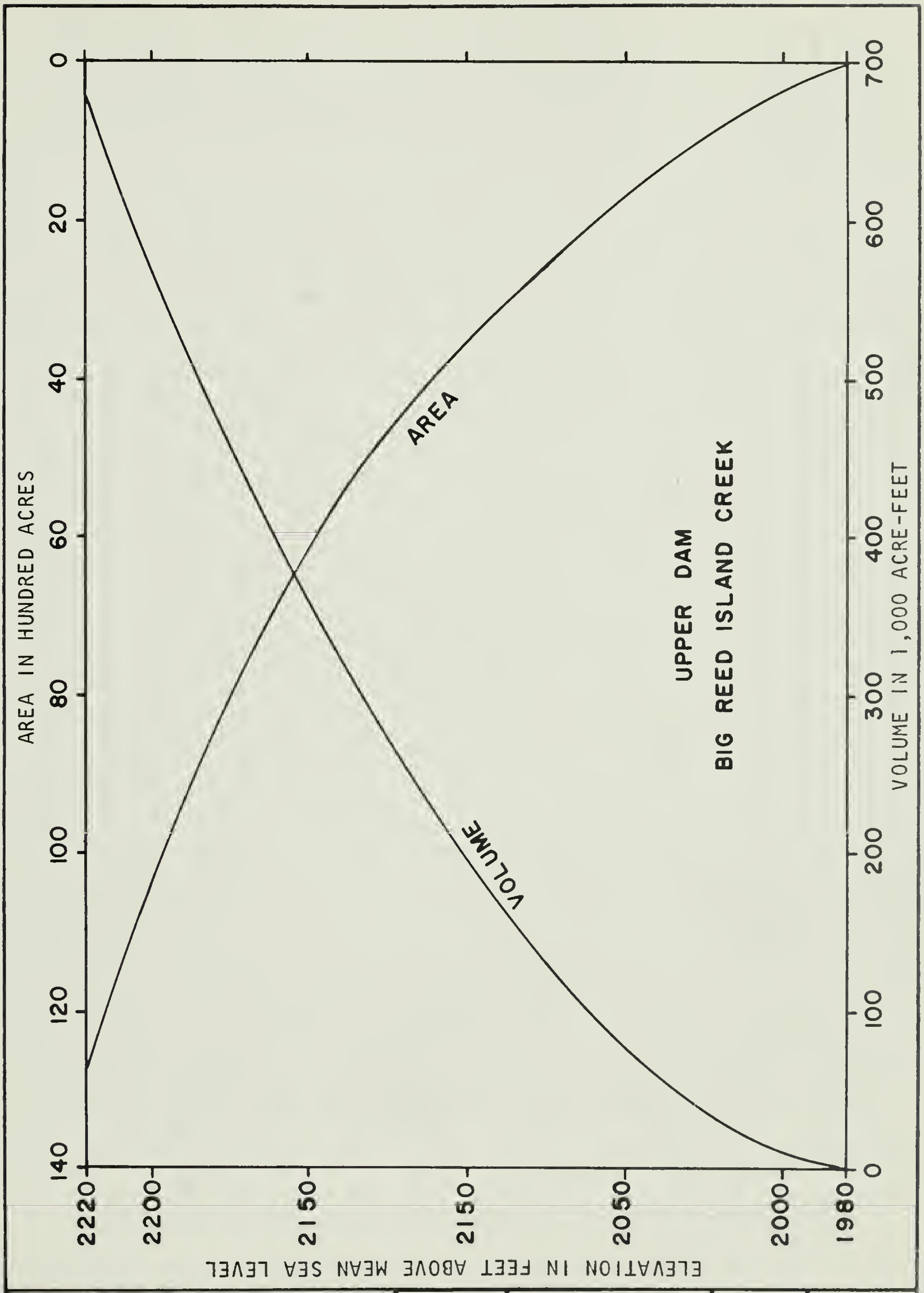

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PLATE NO. 28

capacity increase was made after considering the existing reservoir area, available head, average discharge and the annual output. Estimates were prepared for the addition to and alteration of the existing Claytor Dam for the increased benefits.

It is assumed at this time that the recreation at the lower dam will be affected; however, if the project is ever considered seriously, effort should be made to overcome the difficulties arising from the releases, and every possible effort should be made to keep at a minimum any damage to recreation at Claytor Lake.

Power Capacity. Electric power generated from this project can be absorbed by the utility company serving power supply areas 9 and 10 which are in the States of Virginia, West Virginia, Ohio, and Tennessee. Since the development is a potential project, no effort is made to describe the number of generation units, their size, etc. It is assumed, at this time, that the power generated in the area will be carried over the major utility company's transmission lines present in the area at the time of actual development.

Big Reed Island Creek's upper dam is not solely dependent upon the natural flow but is a pumped storage project. Therefore, it is assumed that there will be no reduction in capacity attributable to low yearly flows. For preliminary purpose, it was estimated that the total capacity of the upper reservoir for electrical generation would be 200,000 kilowatts.

Preliminary estimates indicate that the existing capacity of Claytor Lake of 75,000 kilowatts will be increased to more than 100,000 kilowatts.

Energy Output. Preliminary estimates indicate average annual energy output at the upper dam of 238,000,000 kilowatt hours with an annual pumping energy requirement of approximately 297,250,000 kilowatt hours. An increase in the lower project of Claytor Lake would raise the average annual output of 220,000,000 kilowatt hours to approximately 300,000,000 kilowatt hours, thus producing a gross output increase for the proposed upper and lower dam project of 318,000,000 kilowatt hours.

Operation. Big Reed Island Creek upper project is proposed for peaking power, and the lower dam, i.e. Claytor Lake Dam, will be operated as is now the case with some modifications. The Big Reed Island Creek and Claytor Dam system will be operated on a best-suited output combination with existing and future interconnected systems in the area. The proposed project will provide the utility company in the area with a large amount of peak-carrying capacity and energy. No effort was made to develop in detail the peaking hours, the number of turbines, generators, etc. The following tables show pertinent data relating to the Big Reed Island Creek pump storage project.

Upper Project - Physical Features

1. Drainage area at dam site = 280 sq. mi.
2. Average daily flow = 400 CFS
3. Recorded minimum flow = 68 CFS
4. Recorded maximum flow = 14,500 CFS
5. Average gross head = 310 ft.
6. Efficiency = 85%
7. Total installed capacity = 225,000 kw (upper & lower)
8. Average annual output = 317,800,000 kwh (upper & lower)

Cost Estimates. Cost estimates were based on major items rather than a detailed breakdown on every item. Rates for electrical machinery were adopted from the available costs of other projects in the area with some modification. Total cost of a project was derived from consideration of the preliminary quantities obtained using topographical maps.

Total cost of the upper project is estimated at $60,000,000 while the initial investment required in the lower project would be $11,000,000.

Conclusion. A pumped storage project on Big Reed Island Creek has been studied. The upper reservoir of the project is situated on Big Reed Island Creek approximately two miles from the mouth where it empties into the New River. The lower impoundment is proposed by raising the existing Claytor Dam and increasing the storage available for pump-back purposes. The project seems to be feasible at this time; however, serious consideration would have to be given to possible damage to existing recreational facilities at Claytor Lake. Some adverse comments relative to the desirability of this project have been received by the Division of Water Resources, and any future consideration of the project must take into account the detrimental effects that would result to existing and future development in the area.

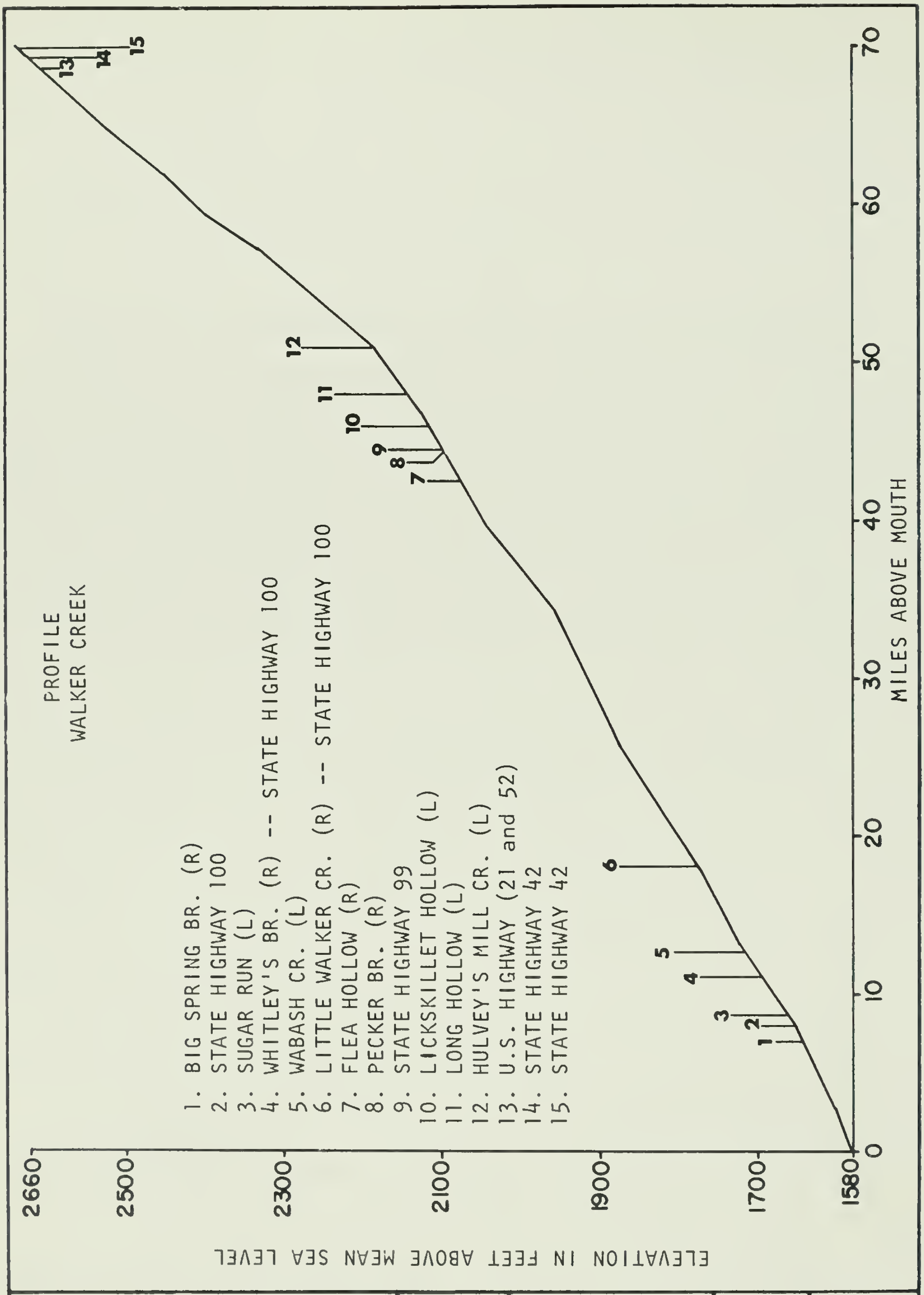
Walker Creek Pumped Storage

Area Characteristics. A pumped storage project is considered for Walker Creek. The lower dam of the pumped storage project would be situated approximately five miles from the confluence of Walker Creek and New River. The upper dam is approximately 12.5 miles from the lower dam. Physiographically, Walker Creek offers excellent sites for a reservoir. Walker Creek runs almost the entirety of its length through a gorge. Preliminary investigations indicated sites selected for upper and lower dam to be satisfactory. However, geological investigations for foundation conditions would be necessary if the project is considered for construction. Approximately 41 miles of secondary highways will be relocated. There are no railroads or major towns involved in this project. Both reservoirs, upper and lower, lie in Giles, Bland and Pulaski Counties. A profile of Walker Creek is shown on Plate 29.

Physical Features of the Upper Dam. The upper dam, assumed for purposes of estimation, is a concrete gravity dam. The top of the upper dam would be at an elevation of 2,260 mean sea level; the approximate height of the dam is 400 feet. The total length of the dam, including dikes, along the center line is 10,000 feet. Rock-filled clay core dikes are assumed on each side of the main structure. Area-capacity curves for the Walker Creek upper project are shown on Plate 30.

Physical Features of the Lower Dam. The upstream elevation of the lower dam is at 1,860 mean sea level, and the downstream elevation is at 1,650 mean sea level. Total length of the lower dam is 2,600 feet. The total storage capacity of the lower reservoir at elevation 1,860 is 400,000 acre-feet. Major portions of flow into the lower reservoir are from the upper reservoir and are obtained during generation of power. Volume of the lower reservoir would be used for peak demands during the week and also pumped back to the upper reservoir on a daily basis. Area-capacity curves for the Walker Creek lower project are shown on Plate 31.

Capacity and Energy Output. Walker Creek possesses excellent potential for pumped storage electrical generation. The growing need of the market area can be met, in part, by the output of the



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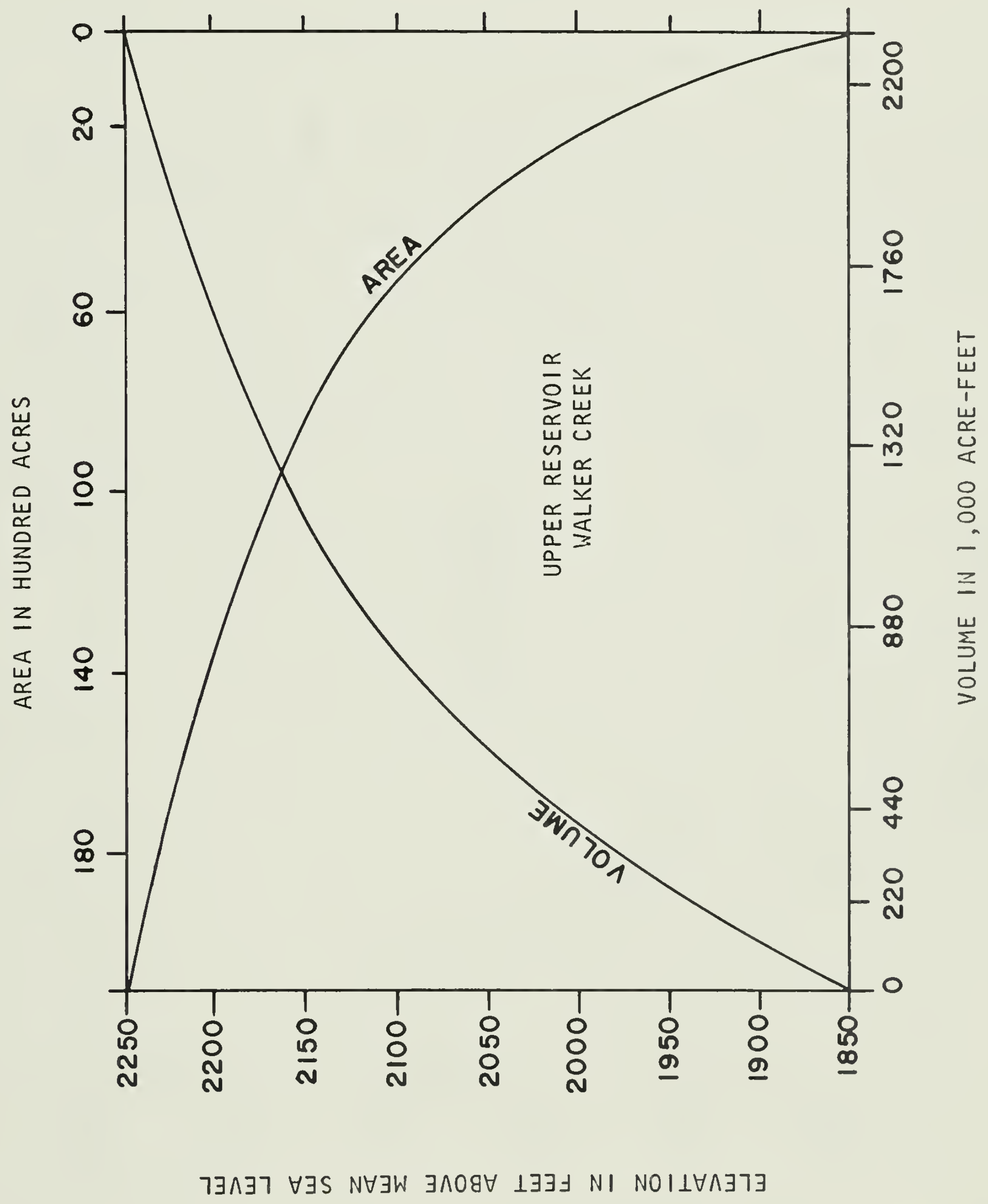
WALKER CREEK PROFILE-N.R.B.	DE.	DR. M.N.F.	APP.	REV.	NO.

PLATE NO. 29



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WALKER CR. UPPER RESERVOIR-N.R.B.	DE.	DR. M.N.F.	APP.	REV.
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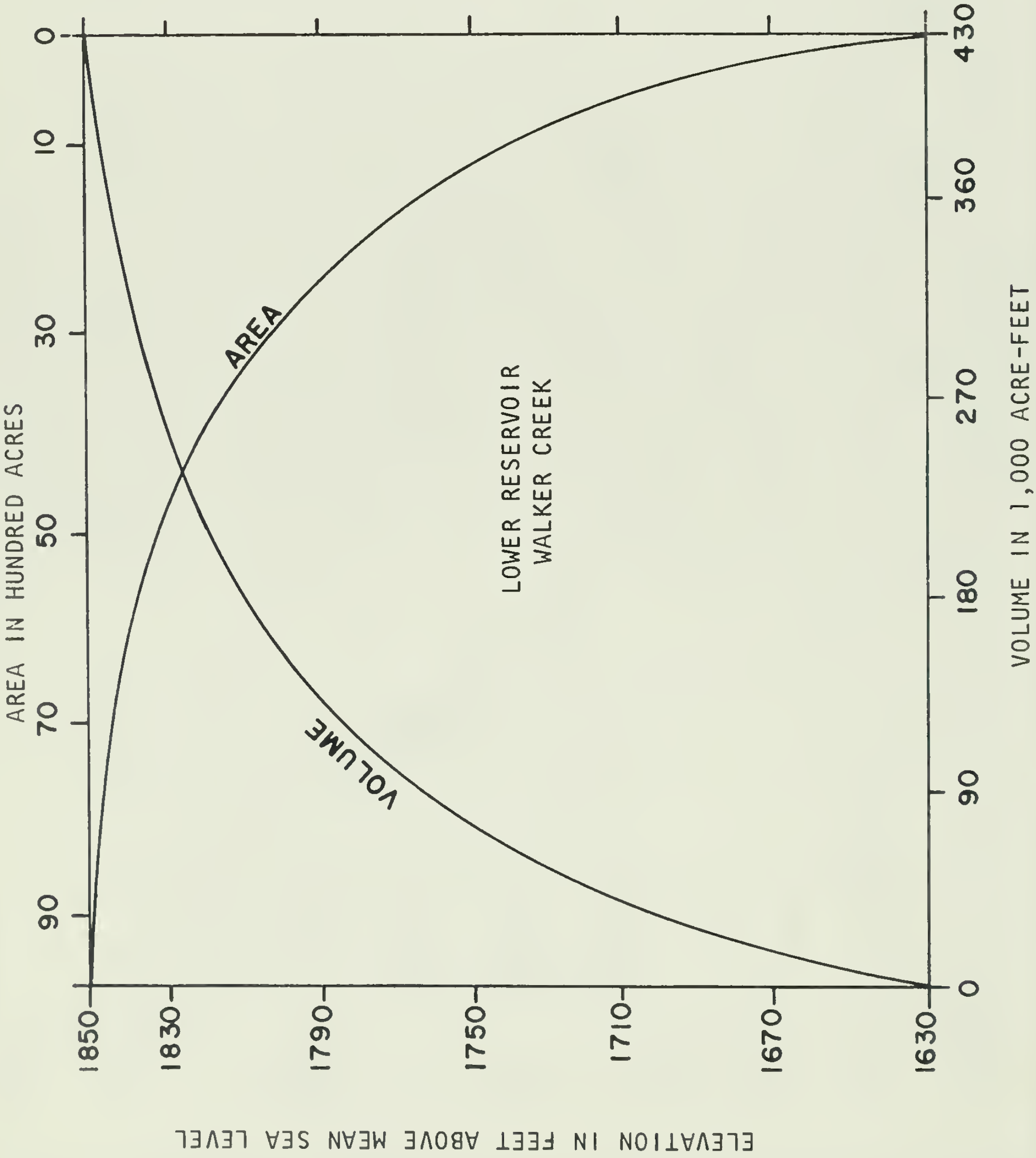
PLATE NO. 30



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WALKER CR. LOWER RESERVOIR-N.R.B.	DE.	DR. M.N.F. APP.	REV.	NO.

PLATE NO. 31

Walker Creek project. Preliminary cost estimates were prepared assuming the energy generated by this project will be carried over the transmission lines of the utility company present in the Basin at the time of development.

Since the project outlined is a pumped storage development, it is assumed that the upper reservoir is not solely dependent upon Walker Creek's natural flow. Because of the dependable flow of pump-back, it is assumed that there will be no reduction in capacity due to low yearly flows. Preliminary estimates indicate that the total capacity of the upper reservoir would be more than 256,800 kilowatts. The lower reservoir would have a total installed capacity of more than 43,100 kilowatts.

Average annual output at the upper project is estimated to be more than 270,000,000 kilowatt hours with an annual pumping energy requirement of 337,500,000 kilowatt hours and a total output of 315,310,000 kilowatt hours. Pump-back energy for delivering water from the lower reservoir to the upper reservoir would be supplied either by fossil fuel steam-electric plants or nuclear energy plants.

This project will be operated on a best-suited output combination with existing and future interconnected systems in the area. At the present time, no effort is being made to develop, in detail, the peaking hours, the number of turbines, generators, etc. The following tables show pertinent data relating to the Walker Creek pump storage project.

Physical Features - Upper Project

1. Drainage area at dam site = 293 sq. mi.
2. Average daily flow in CFS = 300 modified 1070
3. Recorded minimum flow = 15 CFS
4. Recorded maximum flow = 16,500 CFS
5. Average gross head = 400 ft.
6. Efficiency = 85%
7. Total installed capacity = 256,800 kw
8. Average annual output = 270,000,000 kwh

Physical Features - Lower Project

1. Drainage area at dam site = 323 sq. mi.
2. Average daily flow in CFS = 315 CFS
3. Recorded minimum flow = 15 CFS
4. Recorded maximum flow = 16,500 CFS
5. Average gross head = 225 ft.
6. Efficiency = 85%
7. Total installed capacity = 43,100 kw
8. Average annual output = 45,310,000 kwh

Cost Estimates. Cost estimates for this project were based on major items of the project. Total cost of the project was derived from consideration of the preliminary quantities obtained by using topographical maps. Estimated cost of the upper dam is $58,000,000 while the projected cost of the lower dam is $40,000,000. Total project cost is, therefore, estimated as $98,000,000.

Conclusion. A pumped storage project on Walker Creek has been studied. The project appears feasible at this time.

Walker Creek Conventional Hydroelectric Project

The location of this project is in the same approximate area as the lower dam in Walker Creek pumped storage project.

The project shown would be a conventional hydroelectric plant. The reservoir elevation is proposed at a point which will offer the economical head for maximum power output. The average dam height for this project is 400 feet, although, a higher dam could be built.

Project Capacity. It is estimated that the Walker Creek Project conventional plant would have more than 75,700 kilowatts of capacity for peak loads. This project would probably be developed only as a partial substitute for the Walker Creek pumped storage project. Small communities, or the utility company in the area, would benefit from this project if developed properly. Average annual output is estimated at 79,562,000 kilowatt hours.

Cost Estimates. Cost estimates for this project were prepared using the Walker Creek pumped storage project as a guide and considering the size of reservoir, dam length, etc.

Total project cost = $46,600,000
Installed capacity = 75,000 kw
Average annual output = 79,562,000 kwh

Conclusion. A conventional hydroelectric power project on Walker Creek has been studied. Although the project appears feasible, it does not have as great a potential as a pumped storage facility in the same area.

Big Reed Island Creek Conventional Hydroelectric Project

The location of this project is generally in the same area as mentioned earlier in the Big Reed Island Creek pumped storage project.

It is estimated that approximately 18 miles of improved and unimproved highway will need relocation in Pulaski and Carroll Counties.

Physical Features of the Project. Big Reed Island Creek is a conventional hydroelectric project with proposed elevations for the reservoir which will give the most economical head for maximum power output. The dam is proposed at a site approximately two miles above the mouth of Big Reed Island Creek. The top of the dam is at 2,165 mean sea level, and the average dam height is 319 feet.

The length of the dam is approximately 5,000 feet.

Project Capacity. It is estimated that Big Reed Island Creek Project would have a capacity of approximately 72,000 kilowatts if utilized as a peak load station.

Cost Estimates. Cost estimates for this project were based on the Big Reed Island Creek pumped storage project, taking into consideration modified size of the reservoir, the height of the dam and other features of the proposed project.

Total project cost	= $47,000,000
Installed capacity	= 72,000 kw
Average annual output	= 76,000,000 kwh

Proposed Operation. Like other hydroelectric projects, Big Reed Island Creek project is best suited for peaking energy. It will be operated on a best-suited output combination with existing and future interconnected systems in the area. Peaking hours, number of units, and type of turbine and generators have not been studied in detail at this time.

Capacity and Energy Output. Preliminary estimates indicate a total capacity of 72,000 kilowatts obtained from average flow of Big Reed Island Creek. Big Reed Island Creek has a potential for greater heads than those used in the present study.

Conclusion. Big Reed Island Creek is a conventional hydroelectric power project. The dam would be situated approximately two miles above the mouth of the Creek. The project appears to have sufficient potential for further detailed investigation.

Little River Conventional Hydroelectric Project

The proposed dam is situated approximately 18.5 miles from the mouth of Little River. Little River appears to be a suitable stream which can provide adequate head for power production. There is an existing hydroelectric plant, owned and operated by the City of Radford, located on Little River. This project has an installed capacity of 1,000 kilowatts.

The geology of the reservoir area is limestone, and the topography consists of steep hills with vegetation cover. The Little River has cut a gorge through most of the length of the proposed reservoir. Below the proposed dam, and in some upstream areas, a small and narrow floodplain has developed with a varying width of 200 to 600 feet. According to U.S.G.S. topographic maps, the walls of the gorge are timbered and covered with a local, well-developed, residual soil mantle. There are no major railroads or towns requiring relocation.

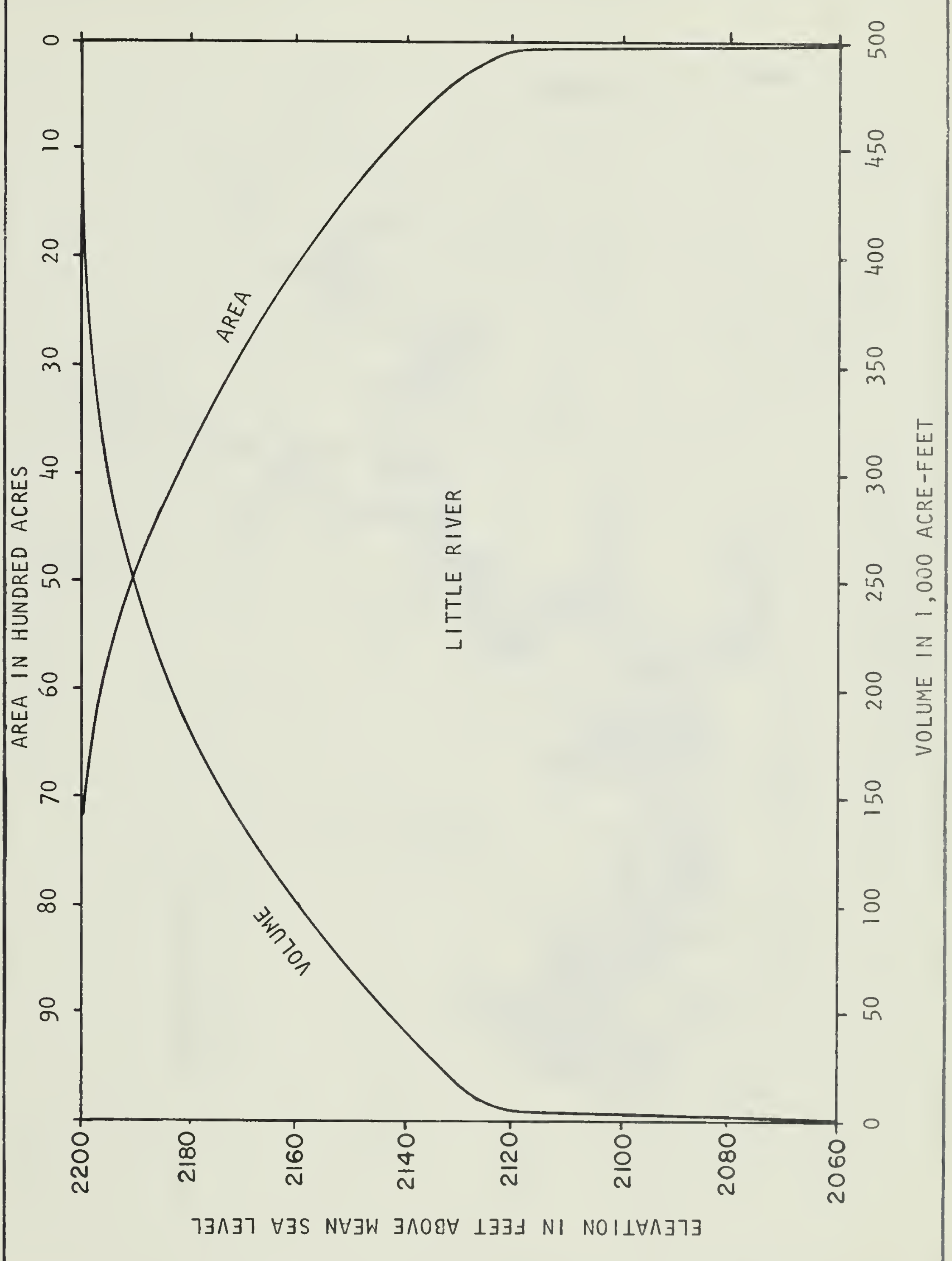
Stream Flow. The dependable output of the power plant was based on flow records of the Little River from 1929 to 1935, with the years 1930 to 1932 having the lowest consecutive years of recorded flow. Average and minimum flows were obtained from the available records for the Little River from October 1928 to December 1965. No attempt was made to determine the effect of variations in seasonal electrical load and the final head at the powerhouse. Consequently, no effort was made to develop the operating schedule of the project. Average annual power output was based on graphic analysis of the mass curve of flows recorded during the seven consecutive years from 1929 to 1935. Recorded minimum flow is 50 CFS and maximum flow of record is 18,500 CFS.

Dam. For estimation purposes, a concrete gravity dam with a controlled section for overflow was considered. Length of the dam is approximately 1,600 feet. Economical height of the dam was selected by comparing the annual cost of power production with varying amounts of storage capacity.

Reservoir. The area-capacity curve for the Little River project is shown on Plate 32. Water surface areas shown in this figure were obtained by planimetering areas at various elevations from topographic survey maps. Rough tail-water rating curves were developed from cross sections obtained from the topographic maps at 1,500 feet intervals and certain additional selected locations in the stream. Preliminary flow computations were based on use of Manning's formula. A map of the reservoir area is shown on Plate 33, and a profile of Little River is shown on Plate 34.

The construction of this dam will require relocation of approximately seven miles of Virginia Primary Road No. 8 and other improved and unimproved secondary roads having a length of 25 miles.

Power Benefits. Preliminary study of the Little River Project indicates that the most economical development of the water resource from the standpoint of power would be total usage of head and storage capacity. It will, of course, not be possible to completely utilize the project for power if other benefits are to be derived. Capacity at this project appears to be excellent for peaking purposes. It is estimated that the power output of this project could well be absorbed by the major electric utility company in the area. The market area for the power generated in the New River Basin is in power supply areas 9 and 10. Average annual output of this project would be more than 39,000,000 kilowatt hours with a total installed capacity of 40,000 kilowatts in an average year. Preliminary investi-



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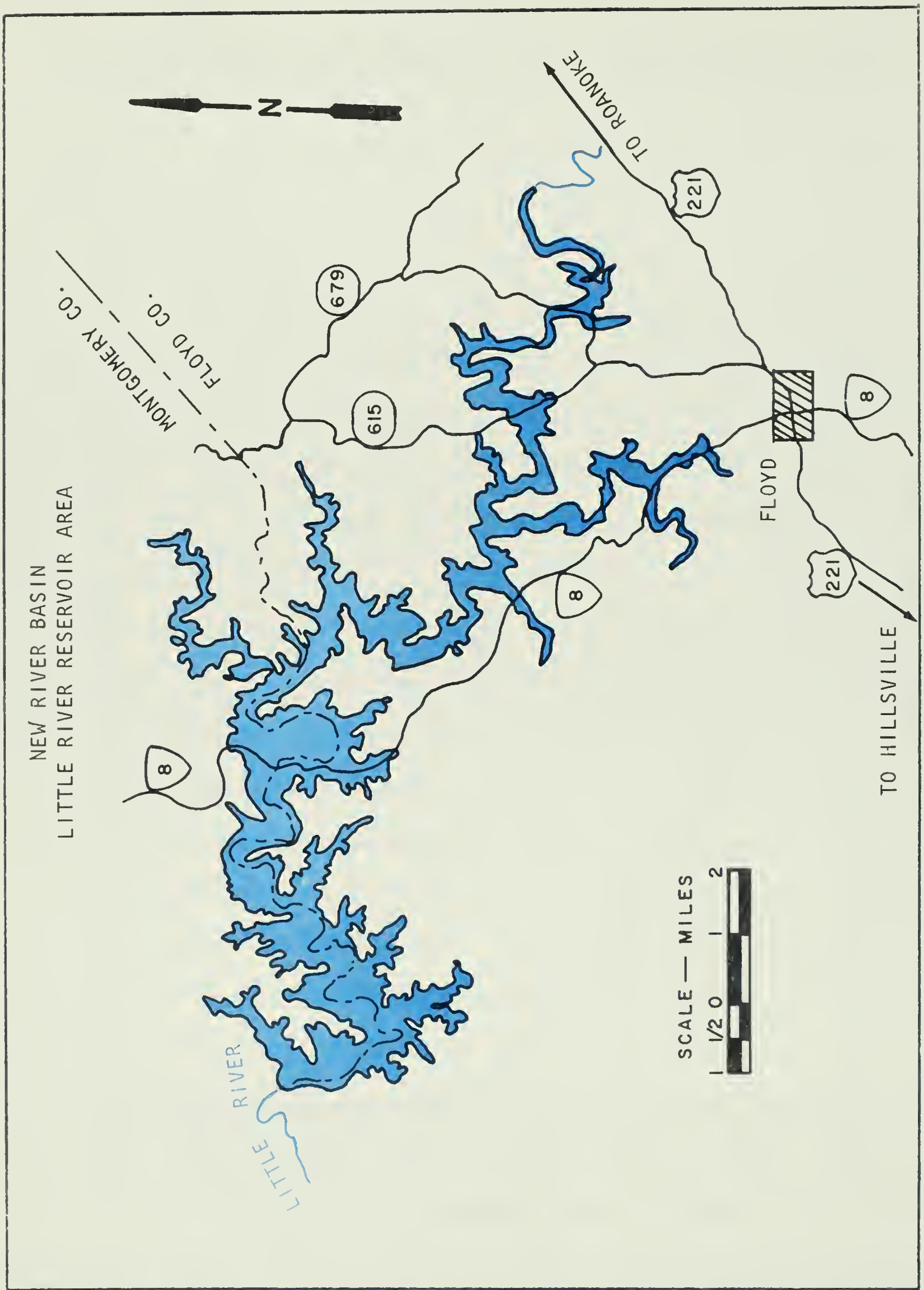

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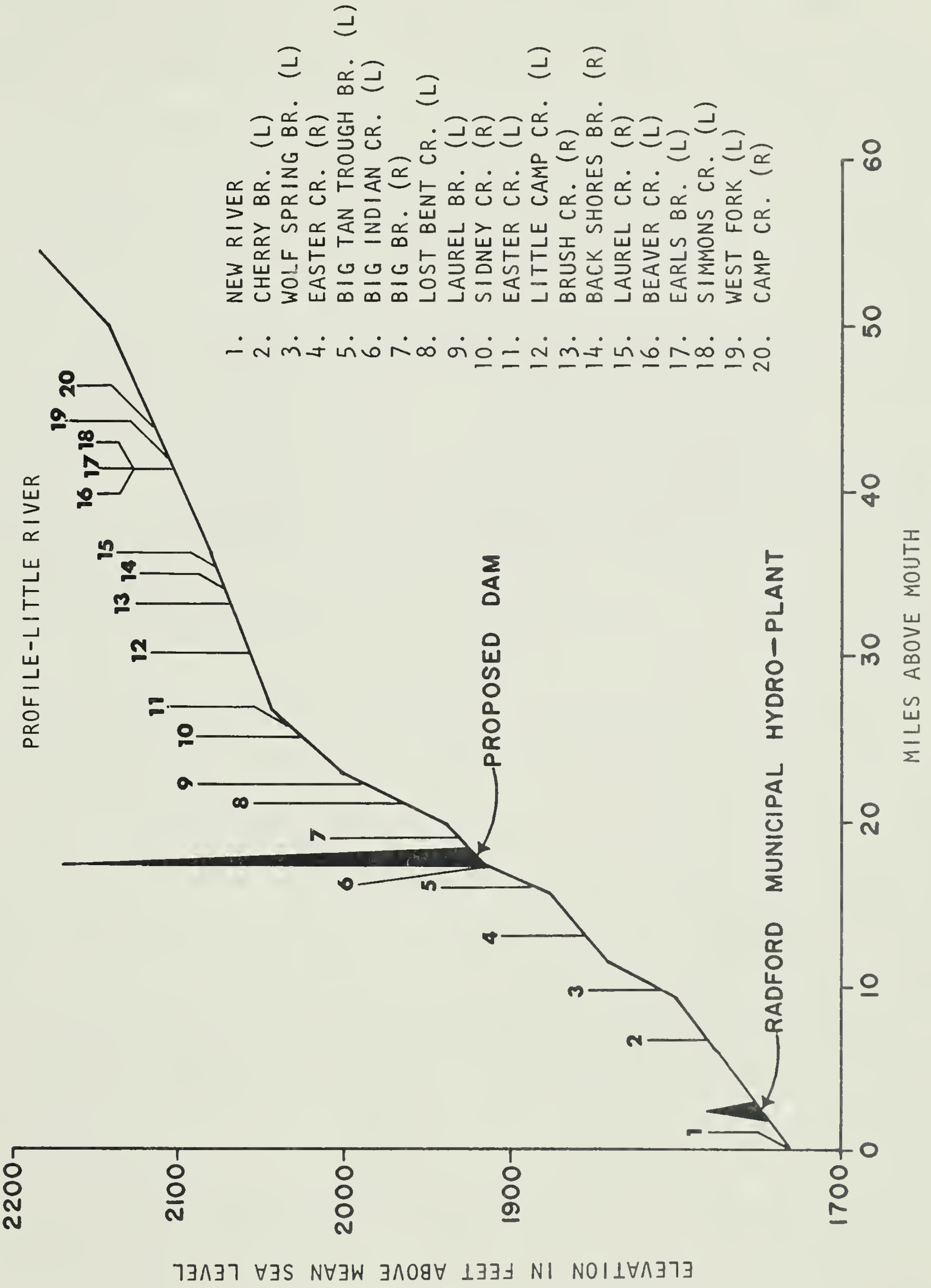
PLATE NO. 33



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gations indicate economical production of power between elevations of 2,130 and 2,160. Annual output at pool elevation 2,160 for the project is shown below. The capacity of the project has been obtained from the regulated flow afforded by the reservoir at elevation of 2,160 and operating on a minimum load factor of 12 percent. The following table indicates pertinent physical features relating to the project.

1. Drainage area at dam site = 232 sq. mi.
2. Average daily flow = 325 CFS
3. Recorded minimum flow = 50 CFS (estimated)
4. Recorded maximum flow = 18,500 CFS (estimated)
5. Average gross head = 200 ft.
6. Efficiency = 85%
7. Total installed capacity = 40,000 kw
8. Average annual output = 39,000,000 kwh

Total cost of the project was estimated on separable items and is $34,000,000.

Conclusion. The Little River project is a conventional hydroelectric project located approximately 18.5 miles above the confluence of Little River and New River. It is suggested that output of this project, if and when developed, be absorbed by the private electric utility company in the area.

Summary of Entire Power Study

The following table contains summaries of power benefits and costs derived from study of five projects in the Virginia New River Basin. The study has evaluated each project from the viewpoint of potential hydroelectric power. Two additional streams appear to have potential for development. However, these streams, Wolf Creek and Reed Creek, have not been evaluated in this study.

Although analysis of projects in this chapter was limited to an assessment of hydroelectric potential, other multipurpose values should be included in any of the potential projects if they are constructed. It should also be pointed out that area-capacity curves shown in Chapter III do not agree completely with area-capacity curves of similar locations shown in Chapter I. The reason for these discrepancies rests in the variation of each project's location and in the fact that study in Chapter III was primarily limited to an assessment of hydroelectric potential.

PROJECT COSTS AND POWER BENEFITS - NEW RIVER BASIN

Project No.	Name of Project	Initial Investment (Million Dollars)	Average Annual Amortization* (Million Dollars)	Annual Power Benefits (Million Dollars)
1	Big Reed Is. Ck. (Pumped Stor.)	71.0	2.9	6.9
2	Walker Creek (Pumped Stor.)	97.8	4.0	9.0
3	Walker Creek (Hydro)	46.6	1.9	2.2
4	Big Reed Creek (Hydro)	47.0	1.9	2.2
5	Little River (Hydro)	34.0	1.4	1.5

* Average annual amortization of initial investment over 50 years at 3¼ percent interest -- does not include operation and maintenance cost.

CHAPTER IV

FLOOD CONTROL

Average annual damages from floods in the New River Basin of Virginia are currently estimated to be $471,000. Of that amount, $57,000 in annual damages occurs along the main stem of the New River and $414,000 annual flood damage occurs on upstream watersheds. This annual monetary loss plus possible loss of life and the continued increase in use of floodplain land make imperative the consideration of flood control measures in any development plan for the New River Basin. Another consideration is the benefit derived in the Kanawha and Ohio River Basin Systems from flood control measures in the New River Basin. It is to be expected that a plan for flood control in the Virginia portion of the New River Basin would consider the Kanawha and Ohio River Basins.

Main Stem

Damaging floods are infrequent along the main stem of the New River in Virginia. Only $57,000 in annual benefits to Virginia can be derived from flood control measures. The inclusion of 160,000 acre-feet of flood control storage in Appalachian Power Company's proposed "Blue Ridge Project" (Moore's Ferry) will protect, substantially, the main stem of the New River from Galax to the Bluestone Reservoir. Moreover, this flood storage adds significantly to the flood protection benefits of the entire Kanawha and Ohio River Basin Systems.

Other structural measures for flood protection along the main stem of the New River in Virginia most probably cannot be justified at this time on the basis of past flood damages alone. However, methods for flood proofing of existing structures on the floodplains should be investigated.

Tributaries

Annual damages along tributaries to the New River in Virginia are approximately $414,000. Those watersheds subject to large annual flood damage include Upper Bluestone River ($79,500) and Peak Creek ($65,500). Flooding along the other tributaries is substantial in certain locations, but generally the damages are widely spread over the watersheds affected.

The U. S. Army Corps of Engineers, Huntington District, has under present investigation six reservoir sites with a total potential flood storage of 226,400 acre-feet based on four inches of runoff at each site. These sites are Walker Creek, Kimberling Creek, Little River, Big Reed Island Creek, Reed Creek, and Cripple Creek. The greater portions of flood control benefits from these sites would be realized in West Virginia and the lower Kanawha River Basin. Projects at those sites are not justifiable at the present time on the basis of flood control benefits to Virginia alone.

Table 1, Chapter I of this Volume, lists 28 other potential sites for reservoirs on tributaries of the New River Basin in Virginia. Those sites were identified from topographic map studies by personnel in the Virginia Division of Water Resources. Those sites identified are capable of controlling approximately 1,200 square miles of drainage area with 4 inches of storage amounting to 256,000 acre-feet. Impoundments at these sites are not needed for flood control in Virginia but would be of value for flood control in the lower Kanawha and Ohio River Basin Systems. They may provide additional benefits to Virginia at a later date as needs may arise. Those tributary sites with the best potential should be integrated into the study for overall development of the New River Basin in Virginia.

The United States Department of Agriculture, (Economic Research Service, Forest Service and Soil Conservation Service), has indicated that four upstream watersheds may be feasible for PL-566 projects within the next 10 to 15 years. These are the Upper Bluestone River, Peak Creek, Little Stony Creek, and Mill Creek watersheds. These projects will reduce the flood damages 90 to 05 percent in these areas, except for the Bluefield, Virginia, area on the Upper Bluestone River which has critical flooding problems. The United States Department of Agriculture and its agencies is rendering an important service to the upstream watershed development plan through the PL-566 investigations program. The continuation of their program is encouraged.

Bluefield, Virginia, Area

Losses from flooding are estimated to be $79,500 annually on the Upper Bluestone River watershed in the vicinity of Bluefield, Virginia. This area has been investigated by the United States Department of Agriculture, and it has been indicated that PL-566 projects appear feasible for this watershed within the next 10 to 15 years. It is noted that the area around Bluefield has serious flooding problems which will not be entirely eliminated through the construction of PL-566 projects, and other methods should be considered in conjunction with the United States Department of Agriculture projects.

All of the flooding problems in Bluefield have not been investigated, and it is recommended that a complete floodplain study be made of the Bluefield area to determine possible alternatives for flood protection. A floodplain study will include the investigation of flood frequency, the determination of flooded areas, and recommendations for a solution to the existing problems. Other solutions may be (1) channel straightening, deepening and cleaning; (2) levees and gates; (3) channel enlargement through removal of constricted openings or enlarging channel capacity; and (4) flood proofing and floodplain regulations.

The residents of the Bluefield area can initiate action to help solve the problems of flooding. The local people may request a floodplain study by the Corps of Engineers with approval from the State of Virginia. This action would provide more knowledge of the existing situation upon which to make a decision and is endorsed by the Virginia Division of Water Resources. Such a study might be eligible for consideration of funds from the Appalachian Regional Commission. The solution to flooding problems in the Bluefield area is important and positive action toward defining the problems more clearly is a necessity.

Floodplain Regulation

Floodplains are those areas bordering a stream which are subject to overflow from the stream with a certain regularity or established frequency. The most common misuse of floodplains is one of encroachment by the construction of a landfill or building, either of which has two effects: (1) Flood waters will damage both the landfill and the building if they are located on a vulnerable area or, (2) the landfill or building will constrict the waterway and cause higher flooding in adjacent upstream areas resulting in damage. Floodplain areas may be used for parks, playgrounds, parking lots, or for placement of inexpensive storage buildings on occasion, and other uses determined by study.

The final plan of structural development for flood control in the New River Basin of Virginia will not completely eliminate all existing and future flood losses. The biggest factor in the alarming rate of rise of flood damages nationally is the misuse of floodplains by persons who are uninformed or who disregard the warning of engineers familiar with the problems involved. Floodplains can be used in the New River Basin as elsewhere, but they should be restricted as to type of use if further and increased economic loss is to be prevented.

The planner must remember, and the responsible officials must realize, however, that Nature's method of discharging floodwaters to the seas will always follow certain paths along waterways and that the most judicious use of these paths or floodplains is accomplished through regulation of these areas.

In the New River Basin of Virginia there are no zoning or building restrictions in existence along the floodplains. At the present time, few areas are subject to floodwater inundation with frequent regularity; therefore, the need for floodplain restrictions is not a serious problem at present.

In looking ahead, more flood control in the Basin coupled with a greater need of desirable land (floodplains) for industrial and residential expansion will create a problem if limitations are not placed upon the use of floodplains. Engineering studies can be made to establish those areas with flooding problems. Appropriate zoning laws and land use laws can be applied which will prevent high annual losses from flood damage. People in the New River Basin should plan for the establishment of zoning or regulatory agencies and adequate zoning to prevent encroachment on floodplains. Failure to do so will probably result in losses resulting from irresponsible use of the floodplains.

Costs Comparison for Flood Control

The Ohio River Basin Comprehensive Survey, Appendix M-Flood Control, and various material from the Kanawha River Basin Study on flood losses indicate that the New River flood problems are minor in comparison with the Basin as a whole. However, the value of every acre-foot of storage for flood control in the Kanawha Basin is approximately the same because of protection for the lower Kanawha Basin and Ohio River area.

In the Ohio River Basin the present total cost of flood protection is approximately $114 per acre-foot of storage. In the year 2020 the projected total cost is estimated to be $300 per acre-foot. The value of flood storage in flood loss reductions is just under $14 per acre-foot annually at present, and by the year 2020 it is estimated to be just over $14 per acre-foot.

In the Kanawha River Basin flood control storage costs $114 per acre-foot, and the value in flood loss reductions has been put at $15 per acre-foot annually. Average annual damage has been estimated at $45,800 per square mile of floodplain in the Kanawha River Basin below Bluestone Reservoir.

In the New River Basin in Virginia annual flood losses are approximately $8,620 per square mile of floodplain. Total annual damages in New River Basin are $471,000, approximately, as compared with $7.04

million in the Kanawha River Basin. Annual benefits from the 160,000 acre-feet of flood control storage in the proposed "Blue Ridge Project" will amount to slightly less than $3 per acre-foot of storage. Any additional storage in the New River Basin for the purpose of flood control in Virginia cannot, then, add materially to flood control benefits in Virginia. In fact, annual benefits per acre-foot of flood control storage measured in flood-loss reduction would decrease, and the difference in costs for storage will, therefore, increase.

However, each acre-foot of flood control storage in the New River will be worth approximately $14 to $15 annually in flood loss reduction in the Kanawha and Ohio River Basins. The costs per acre-foot of flood storage will vary from approximately $115 now to $300 by the year 2020. If the potential sites for reservoirs in the New River Basin shown in Table l, Chapter I of this Volume, are utilized to control four inches of runoff from floods, the value of the flood storage available (600,000 acre-feet) would be approximately $9 million annually in flood damage reductions in the Kanawha and Ohio River Basin Systems. The total costs of these projects, using a 1965 price base, is estimated to be $68 million.

Summary

Flood control is not a serious problem in the New River Basin in Virginia. The savings realized in the New River Basin based on flood loss reduction attributed to flood control storage are four to five times less than the average savings in flood loss reduction from flood control storage in the Kanawha and Ohio River Basins of which New River is a part.

Based on past flood records, the planned "Blue Ridge" facility proposed by Appalachian Power Company would reduce flood damages along the main stem of the River in Virginia by 99 percent. Agencies under the United States Department of Agriculture are investigating upstream watersheds and recommending projects to alleviate flooding conditions where feasible on these tributaries. The Bluefield, Virginia, area needs to investigate the special flood problems in their area, and a floodplain study is recommended. In most tributary areas, the losses due to flooding are not sufficient to warrant the cost of flood control measures alone, but flood control can be justified in most areas where multipurpose reservoirs are planned.

It is believed that floodplain regulation must be employed in any development plan for the New River Basin to prevent flood losses from becoming greater in the future, regardless of the structural measures planned.

The New River in Virginia has many potential sites for flood control structures. These structures would be most beneficial to the Kanawha and Ohio River Systems, because the need for flood control storage in these larger, more developed basins is greater than in the New River. If these structures are built, multipurpose values must be included if Virginia residents are to benefit.

More refined investigations into flood control needs are indicated for the future in the tributary areas of the New River as flooding problems arise, but an orderly development scheme recognizing flood control as a factor should eliminate the majority of all flood problems in Virginia and provide a share of flood control to the comprehensive Ohio River Basin System.

CHAPTER V

ULTIMATE DEVELOPMENT POSSIBILITIES

Potential Value of New River Water

An important consideration in the analysis of a resource is an understanding of the potential worth of the resource. It should be understood that potential value can only be transferred into real value if the resource is utilized. The following discussion attempts to evaluate the water in the New River from the standpoint of water supply, pollution assimilation, thermal-electric generation cooling, hydroelectric power, recreation, and flood control. There are other values attached to water which are not evaluated from a monetary view because of the difficulty of analysis. These values include, among others, irrigation and the recreational value of the running stream.

Water Supply. The value of water for public water supply has been based on the cost of development and transmission of raw water to the point of treatment or need. A figure of $0.05 per 1,000 gallons has been used in the calculation. Because of quality limitations, a means of establishing some practical limits on the quantity of water that can be utilized for public supply is necessary. A limitation of one gallon out of each 20 gallons of flow in the River is used in the analysis. This limit is used since most water withdrawn for public supply will be returned to the stream as waste effluent. The dilution afforded by the remaining water in the stream will insure a river of high quality from both the standpoints of oxygen demand

and nitrogen and phosphorous concentration provided some nutrient removal is practiced.

The value of water for industrial use has been based on the use of 4 gallons out of each 20 gallons for industrial supply. This limitation has been based upon consideration of the industrial waste effluent which will occur as a result of industrial water intake and its effect on water quality. The dilution afforded by the remaining water in the stream will insure a river of high quality provided some nutrient removal is effected.

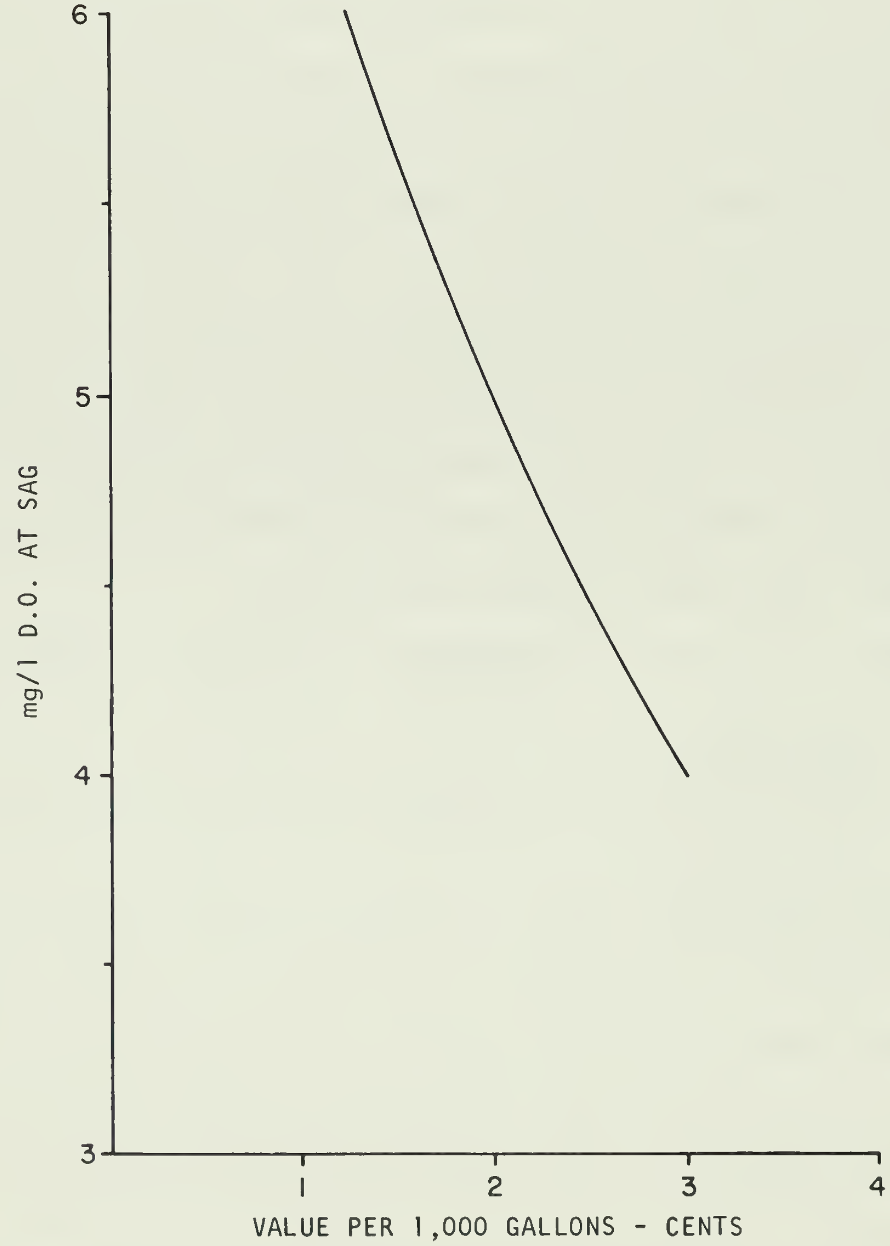
The following table expresses the annual average value of water for water supply under three assumptions of flow at Radford - 600 CFS, 1,200 CFS (flow which will result from 50,000 acre-feet of low flow augmentation from the proposed Blue Ridge Project), 1,872 CFS (50 percent regulation of average flow at Radford).

Flow	600 CFS	1,200 CFS	1,872 CFS
Value of Public Water per year (1966 Dollars)	$353,000	$706,000	$1,101,000
Value of Industrial Water per year (1966 Dollars)	$1,412,000	$2,824,000	$4,404,000

Waste Assimilation. The value of water for waste assimilation is based upon the cost of treating waste by secondary treatment processes to achieve a stated value of dissolved oxygen. An objective of a 5 mg/l minimum dissolved oxygen concentration was used. This level of dissolved oxygen will permit the water to be used for almost any purpose.

Plate 35 illustrates the relation between dissolved oxygen and the value of the water to obtain a given standard in the New River Basin. The curve was derived from relationships of dissolved oxygen,

VALUE OF NEW RIVER WATER IN SECTION II FOR ORGANIC WASTE ASSIMILATION



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river flow, and quantities of waste presented in Volume IV of the New River Basin Comprehensive Water Resources Plan. Examination of Plate 35 reveals, at first glance, what appears to be a paradox. The value of the water as an assimilative medium is reduced as the dissolved oxygen concentration rises. In other words, the water is worth more for assimilation at the lower dissolved oxygen values. This is true since the rate of reaeration is greater at lower dissolved oxygen levels than at higher levels or values approaching saturation, and the limiting value of oxygen that can be reached in an unpolluted stream is the saturation value. The following table expresses the annual average value of water in Section II of the New River for waste assimilation:

Flow	600 CFS	1,200 CFS	1,872 CFS
Value of assimilative water per year (1966 Dollars)	$2,840,000	$5,680,000	$8,860,000

Thermal-Electric Generation Cooling. The value of water for thermal-electric generation was based upon the cheapest alternative to once-through cooling, i.e. cooling towers, and a limit of 10 degrees F. temperature rise in return water. Analysis of tower cost and operation indicated that for water to be competitive with off-stream cooling it should have a value of $0.003 per 1,000 gallons. For the purpose of analysis, the cost of operation was limited to a 180-day period since the need for large quantities of cooling water does not usually exceed this period. The following table indicates the annual average value of water in Section II of the New River for thermal-electric generation cooling.

Flow	600 CFS	1,200 CFS	1,872 CFS
Value of cooling water per year (1966 Dollars)	$207,000	$414,000	$647,000

Hydroelectric Power Generation. The valuation of potential hydroelectric power has been based upon the cost of developing the energy and the benefits from the sale of energy. Three levels of development are assumed, and these levels are reflected in flows of 600 CFS, 1,200 CFS, and 1,872 CFS at Radford gage. The value of power under a flow regime of 600 CFS is that realized under current development in the Basin. The value of power under 1,200 CFS is that which is possible under existing development and the proposal of the Appalachian Power Company at Blue Ridge. The value of power under 1,872 CFS is based upon the sum of existing development, the Blue Ridge Project, and additional development in Virginia necessary to insure approximately 1,872 CFS at Radford.

Flow	600 CFS	1,200 CFS	1,872 CFS
Value of power per year (1966 Dollars)	$3,500,000	$26,000,000	$34,800,000

Recreation. The ultimate potential value of recreation in the New River has been based upon the potential recreation which could be developed in existing and future reservoirs in the Basin. A 50 percent regulation of average flow at Radford was assumed, and reservoirs which would produce this level of regulation were analyzed for recreation potential.

Two important parameters used in the evaluation of recreational potential of reservoirs are the length of shoreline and the water surface area. It has been assumed that a maximum drawdown of 10 feet will occur and that there will be no appreciable loss of value in impoundments utilizing this drawdown as opposed to impoundments with a completely stable pool. Provision of suitable recreation facilities to insure maximum potential have been assumed.

The value of recreation has been calculated under two different sets of assumptions, and the selected values represent an average of the figures calculated. The first values under various flow regimes in the following table assume a usage of 167 recreation-days per water-surface acre and an expenditure of $2.63 by each user. The second set of values indicated assumes 500 visitors per acre of park area, a developed shoreline of 50 percent of the total shoreline, 50 acres of park area per mile of developed shoreline, and an average expenditure of $2.63 per person. The flow of 600 CFS represents existing development, 1,200 CFS represents the existing development plus the Blue Ridge Project, and 1,872 CFS is based on the sum of existing development, the Blue Ridge Project, and additional development in Virginia necessary to insure 1,872 CFS at Radford.

Flow	600 CFS	1,200 CFS	1,872 CFS
Value of recreation based on surface area	$1,980,000	$7,680,000	$11,700,000
Value of recreation based on park development	$1,980,000	$18,430,000	$25,660,000
Median value of recreation	$1,980,000	$13,055,000	$18,680,000

Flood Control. Flood control is based upon the reservation of 4 inches of runoff storage in reservoirs which would afford 50 percent regulation of average flow at Radford plus 160,000 acre-feet for flood control in the proposed Blue Ridge Project. At the present time, flood control on the main stem of the New River in

Virginia consists almost entirely of the flood storage in Claytor Reservoir.

The following tabulation indicates the benefits to Virginia by flood control in reservoirs which will assure various low-flow regimes:

Flow	1,200 CFS	1,872 CFS
Value of flood storage to Virginia per year	$57,000	$62,000

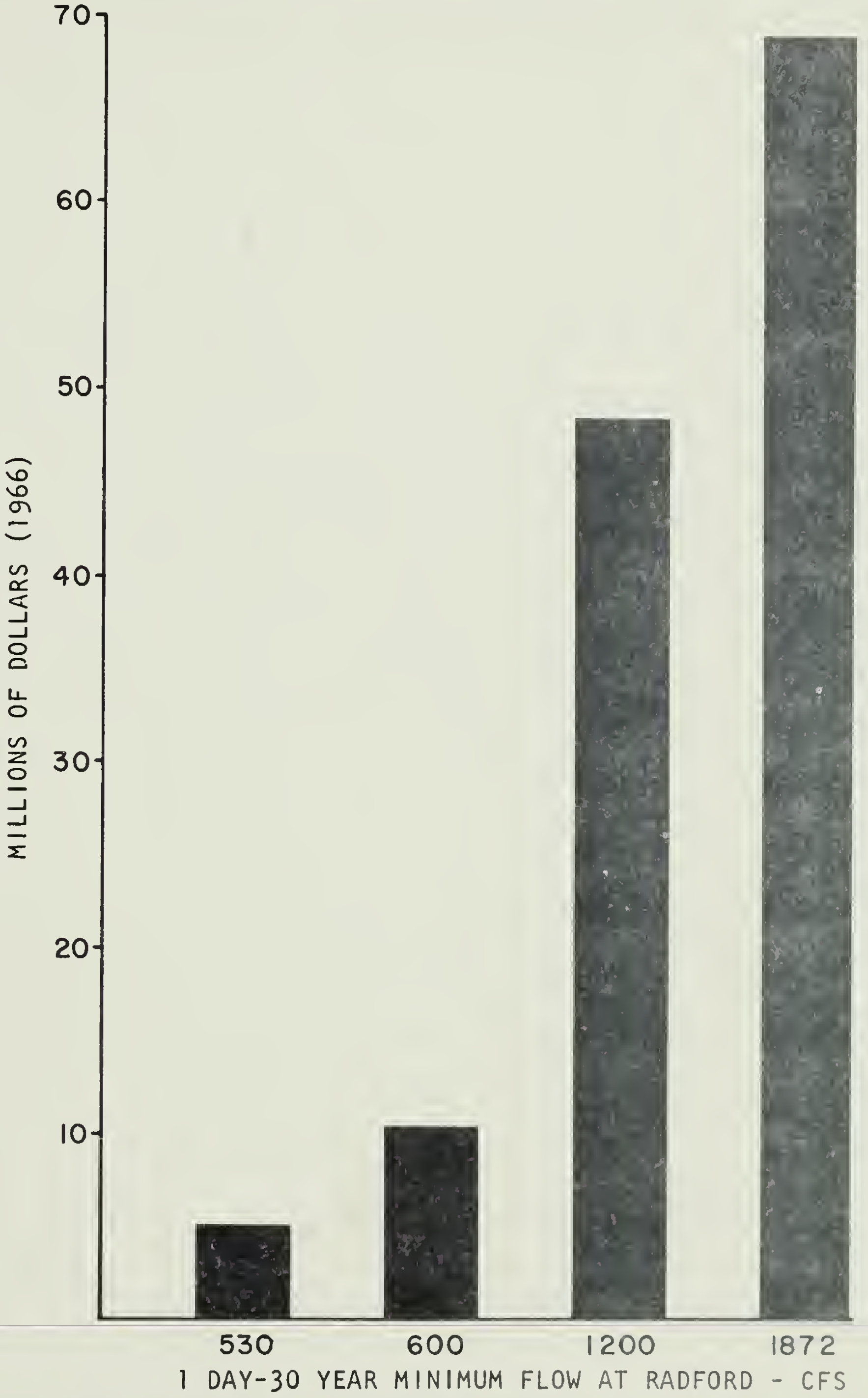
The proposed Blue Ridge Project will reduce the major portion of damages along the main stem in Virginia, and although additional development in Virginia will further reduce damages, the major value of the flood control portion of the reservoirs will be felt in other states.

Summary of Potential Value of New River Water in Virginia

Plate 36 shows the potential value of New River water and associated development in Virginia under various low-flow regimes. The value shown for 530 CFS is the value that would occur with the existing Buck and Byllesby Reservoirs as the only River development. This value is then roughly a base-line figure from which increases in various increments of development can be measured. The flow of 600 CFS represents development incorporating Claytor Lake. The value associated with 1,200 CFS represents all existing development plus the proposed Blue Ridge Project. The worth associated with 1,872 CFS is the value of the water and associated development if 50-percent regulation is accomplished at Radford.

The striking feature of the Plate is the tremendous increase in potential value which will occur as a result of a balanced Blue Ridge Project. Plate 37 indicates the monetary worth per CFS of

POTENTIAL ANNUAL VALUE OF NEW RIVER WATER AND ASSOCIATED DEVELOPMENT IN VIRGINIA



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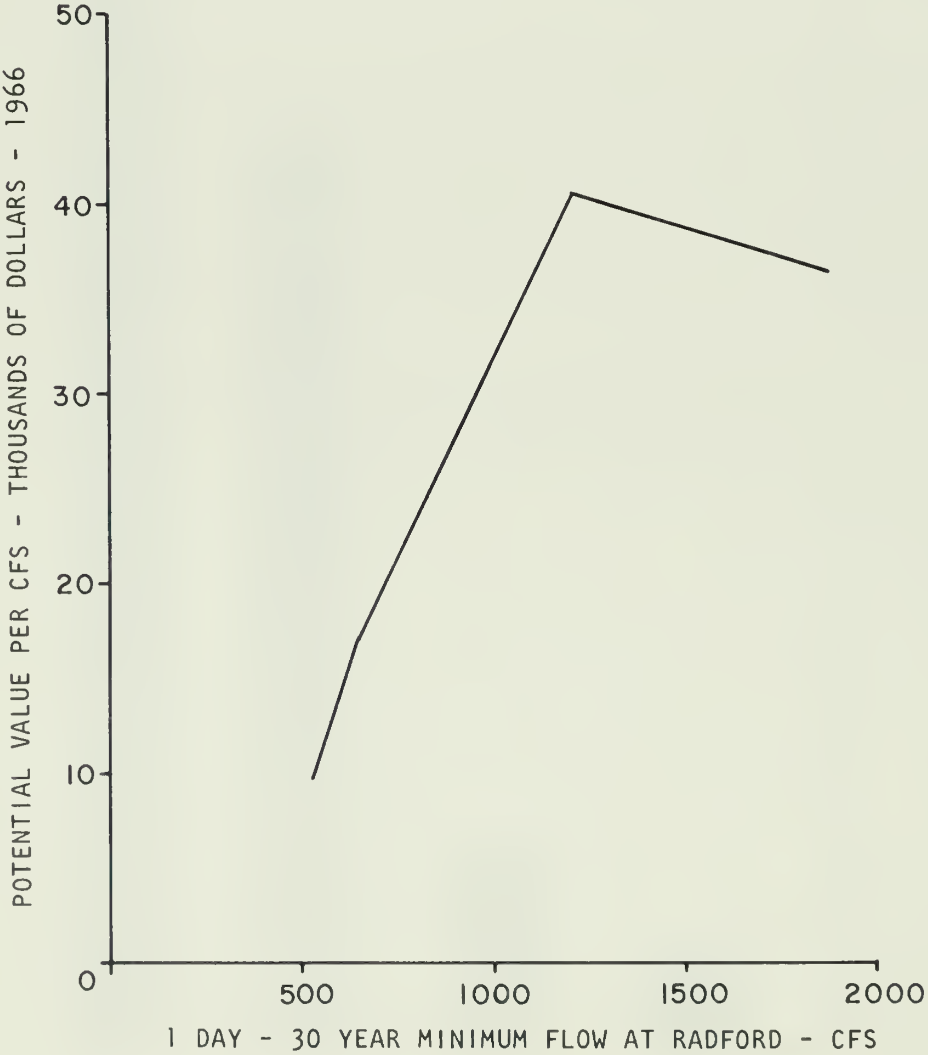
POTENTIAL ANNUAL VALUE OF NEW RIVER WATER AND ASSOCIATED DEVELOPMENT IN VIRGINIA



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VALUE OF NEW RIVER WATER PER CFS OF FLOW	DE.	DR. M.N.F.	APP.	REV.	NO.

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flow. The peak figure per CFS is that associated with the existing development plus that of the Blue Ridge Project.

The estimated cost of developing the Blue Ridge site is $150,000,000. Assuming a 4.5 percent interest rate and repayment life of 50 years, the annual average cost including operation and maintenance will be approximately 3.5 million dollars per year. The ratio of potential increased benefits, over those derived from current development, to cost is approximately 5 to 1. This ratio includes an initial expenditure necessary for ultimate recreational development. It should be emphasized that the above costs and the benefits of development are based upon the premise that the site is developed to its ultimate potential. Later discussion in this Chapter indicates the potential available under two specific project plans.

It is therefore apparent that development of the Blue Ridge site can be the cornerstone of development in the Virginia New River Basin. A project properly used for power generation, flow augmentation, and recreation has enormous potential for the area and the State.

Value of New River Water and Associated Development to West Virginia

Certain benefits of development in Virginia are realized in West Virginia. All of the benefits are not shown in this Chapter; however, two tangible benefits have been evaluated. The operation of Claytor Reservoir has resulted in increased flow entering West Virginia. The amount of water used each year in this augmentation is estimated at 30,000 acre-feet. The construction of Blue Ridge Reservoir will make 160,000 acre-feet of flood storage available to West Virginia as 130,000 acre-feet of reallocated water-quality storage. In other words, if the Blue Ridge Project is constructed, 130,000 acre-feet of storage now reserved in Bluestone Reservoir for flood control could be filled and used seasonally for water-quality control at Bluestone. The 50,000 acre-feet of water quality storage will also be available for benefit in West Virginia.

The following tabulation shows the potential value to West Virginia of impounded water in Virginia necessary to assure certain minimum flows at Radford. The table also includes value of flood control reallocated to water-quality storage at Bluestone Reservoir. All calculations are based upon a figure of $6.00 per acre-foot of storage and a maximum drawdown of 10 feet in each reservoir.

Flow	600 CFS	1,200 CFS	1,872 CFS
Value of water-quality storage and reallocated flood storage per year (1966 Dollars)	$180,000*	$1,260,000	$2,517,000

* Includes only 30,000 acre-feet of water-quality storage and does not include reallocation of flood storage.

Potential Value of the Blue Ridge Project

As previously outlined, the proposed Blue Ridge Project, if properly managed, will be of great value to the State of Virginia. An analysis of the project under two proposed management plans has been made. These plans represent a scheme of management proposed by the Virginia Division of Water Resources and a scheme recommended by the United States Department of Interior. It should be pointed out that in neither plan are the potential values at the 1,200 CFS point indicated on Plate 36 completely realized. The potential values shown in Plate 36 can be considered as goals against which development benefits can be measured.

The Division of Water Resources' plan includes provision for

50,000 acre-feet of water-quality storage. This water would be released over a 90-day period to augment downstream summer flows. The total drawdown including the allowance for power generation and flow drawdown including the allowance for power generation and flow augmentation would be 10 feet. Eleven separate value classifications have been analyzed. These classifications are as follow:

1. The direct tax benefits to the local counties from privately owned power facilities are estimated at $300,000 per year upon completion of the project in 1975, increasing to $500,000 per year in the year 2020. These benefits are estimated under a 10-foot drawdown limitation and the provision of a State Park and other recreation developments that will require electrical service.

2. The value of local county real estate tax on private recreation developments, sales tax, increased gasoline tax, and State income tax generated by the project is estimated at $230,000 per year in 1975 increasing to $1,300,000 in 2020.

3. The potential value to recreation users is estimated at $2,250,000 in 1975 and $3,000,000 in 2020. These figures are based upon the allocation of 75 percent of the total recreation benefits to Virginia.

4. The potential value of public water supply was estimated on the basis of 600 CFS added to the Radford gage on a 1-day 30-year minimum flow occurrence. The potential value added for water supply is $353,000 annually.

5. The potential value of industrial water supply added by the Blue Ridge Project on the basis of an additional 600 CFS at Radford gage is $1,424,000.

6. The potential value for waste assimilation added by 600 CFS of flow at Radford gage is $2,840,000 annually.

7. The potential value for thermal-electric generation cooling added by 600 CFS of flow at Radford gage is $207,000 annually.

8. The potential value in annual flood reduction benefits to Virginia is estimated at $57,000.

9. The potential value of power in the project with 10 feet of drawdown is $18,836,000 per year.

10. The value in West Virginia for 50,000 acre-feet of water-quality storage is $300,000 per year. This figure is based upon a value of $6 per acre-foot of storage.

11. The potential value of 160,000 acre-feet of flood-control storage at Blue Ridge for reallocation at Bluestone Reservoir in West Virginia in the form of water quality storage is $780,000 annually. This figure is based upon the assumption that 160,000 acre-feet can be transferred to 130,000 acre-feet of water-quality storage at a value of $6 per acre-foot.

The Department of Interior's plan includes the provision of 500,000 acre-feet of water-quality storage which would be released during a 90-day period. Reservoir drawdown under this plan would be 50 feet. An analysis of the scheme proposed by the Department of Interior follows:

1a. Little or no expansion around the reservoir is contemplated under the restraint imposed by the drawdown proposed by the Department of Interior. A direct tax benefit of $300,000 is, therefore, assumed over the period of analysis.

2a. The value of local county real estate tax on private recreation developments, sales tax, increased gasoline tax, and State income tax generated by the project will be reduced to $23,000 per year in 1975 and $130,000 per year in 2020. This reduction is due to the project drawdown and the unlikely situation that large-scale recreation and associated development will take place.

3a. The potential value to recreation users will be reduced to $225,000 per year in 1975 and $300,000 annually in 2020. This reduction would primarily result from the fact that no State Park would be built under Interior's proposal.

4a. Under the Interior proposal, flow could drop to 260 CFS below the reservoir during refilling of the 500,000 acre-feet drawn for water-quality control. Since the dependable flow would, therefore, only be 600 CFS at Radford gage and this is the existing flow, no added value for public water supply would occur.

5a. No additional value attributable to industrial supply would occur because flows during refilling would approximate those occurring now.

6a. No additional value attributable to waste assimilation can be assumed in Virginia since minimum flows during refill would approximate those occurring now.

7a. The potential value for thermal-electric generation cooling water would be increased by $207,000 annually. This increase will be realized since release of the augmentation water will occur during periods of greatest cooling water need.

8a. The potential value of flood reduction would be the same under either plan of management - $57,000 per year.

9a. The potential power benefits would be reduced under the

Interior plan to an annual potential power value of $18,108,000.

10a. West Virginia benefits under the increased amount of water-quality storage would be increased to $3,000,000 annually.

11a. The potential value for flood storage reallocated to water-quality control at Bluestone Reservoir would be the same under either management plan - $780,000 per year.

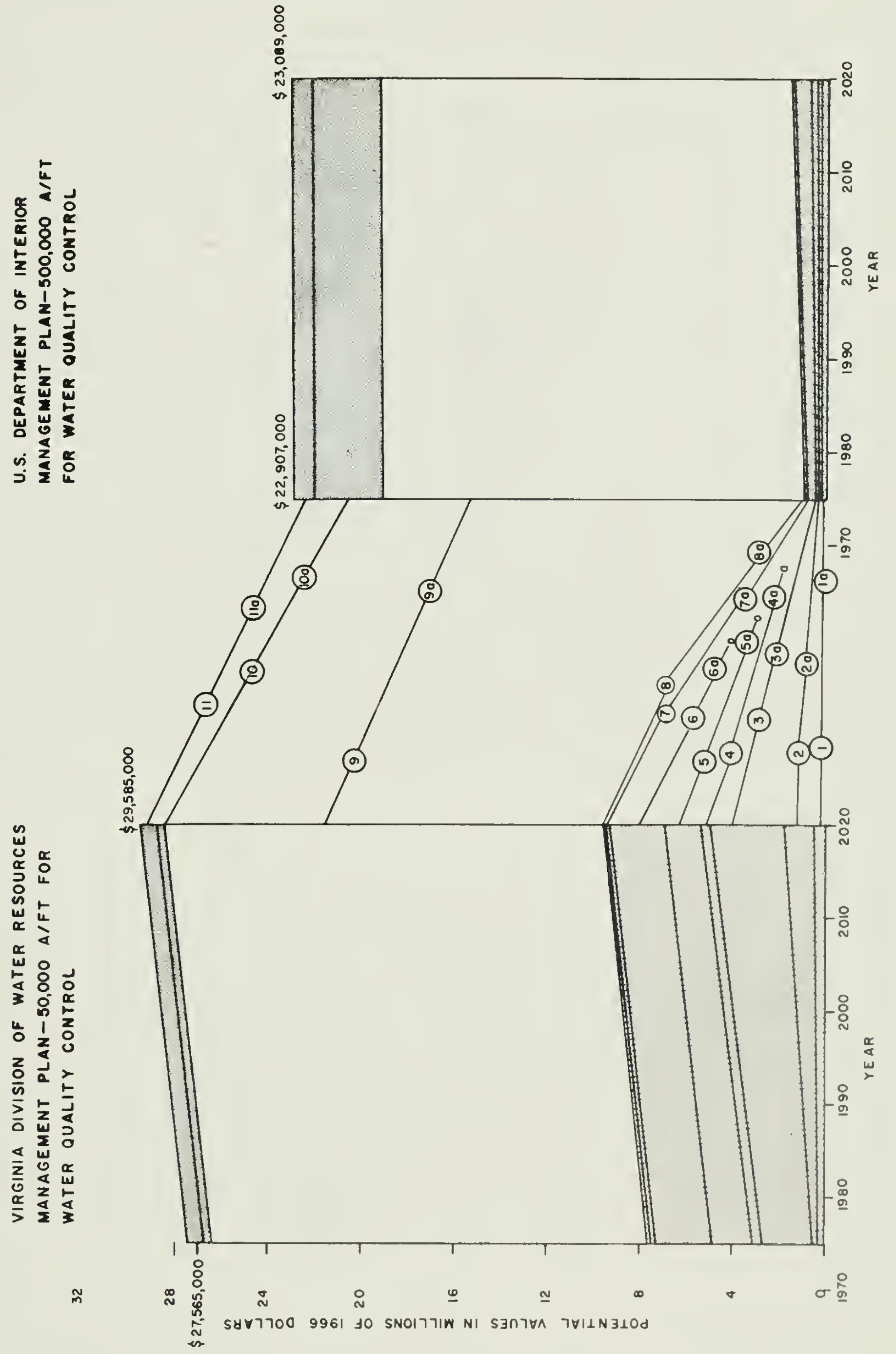
Plate 38 shows a comparison of the project under the two management plans. In summary, the Plate indicates an overall non-power value reduction of approximately 7.5 million dollars if the Department of Interior proposal is selected over the Division of Water Resources' proposal. Although the State of West Virginia would gain under Interior's plan, this gain would be greatly offset by the loss to Virginia.

It is, therefore, apparent that balanced management of the project is essential if Virginia is to receive optimum benefit.

Location of Reservoirs Necessary for Ultimate Development

At the present time, it is felt that ultimate development possibilities in the Virginia New River Basin would be filled by provision of sufficient projects to insure a minimum 1-day 30-year low flow at Radford gage of 1,872 CFS. Although there are a number of tributary reservoir sites which could be developed, attention has been focused upon three proposed locations under study by the United States Army Corps of Engineers. These sites are located on Little River, Big Reed Island Creek, and Reed Creek and are shown on Plate 39. It should be emphasized that these are not the only sites which are available for meeting the ultimate development goal, and at the present time the sites are under a preliminary engineering study. Construction of a reservoir project on Reed Creek would, in fact, destroy an existing

POTENTIAL PROJECT VALUES - BLUE RIDGE



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fish hatchery. If the need for additional water is indicated in the Basin, the location of a reservoir in this area would have to be weighed against the loss of the hatchery.

Assuming these reservoirs are constructed, the following quantities of storage could be utilized under the restraint of a 10-foot drawdown during the critical 90-day summer period.

Site	Storage Available Under Restriction of 10-foot Drawdown Acre-Feet	Flood Control Storage (4 Inches of Runoff) Acre-Feet
Little River	27,500	42,240
Big Reed Island Creek	40,000	55,200
Reed Creek	18,000	55,080

It is also possible that a reservoir site in North Carolina could be developed to produce 50,000 acre-feet of water-quality storage under nominal drawdown. This storage, if developed, would of course be available for increasing the flow in the New River in Virginia during the summer months.

With a 10-foot limitation on drawdown in the reservoirs, it is felt that considerable recreational value would be realized. In any future consideration of these sites a balanced scheme of management must be planned. Chapter VI of this volume presents a possible regulation scheme for a combination of the proposed Blue Ridge Project, three additional projects in Virginia and a project in North Carolina.

RESERVOIR SITES
NEW RIVER BASIN IN VIRGINIA
DRAINAGE AREA GREATER THAN 10 SQUARE MILES

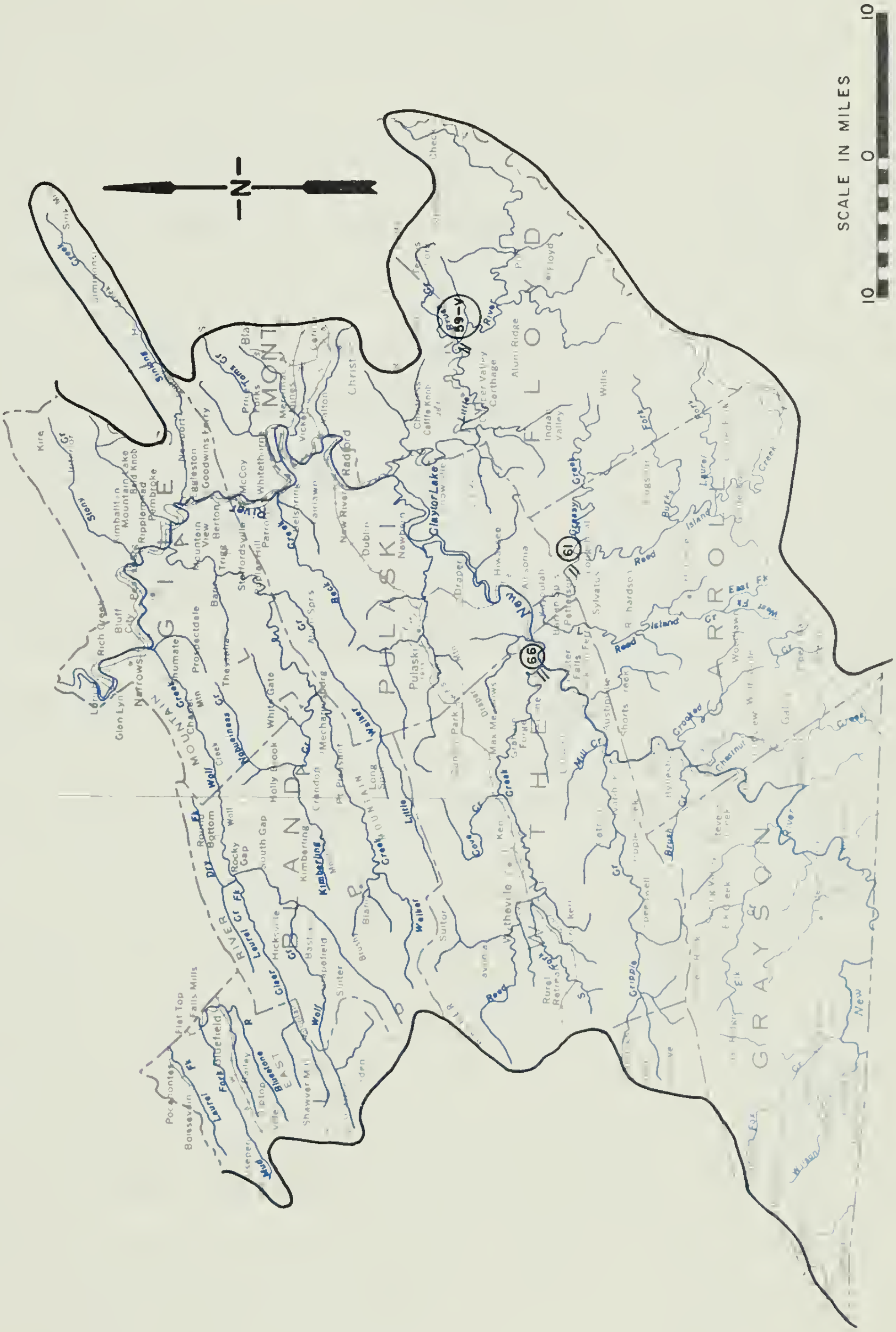

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PLATE NO. 39

CHAPTER VI

FLOW REGULATION ANALYSIS - ULTIMATE DEVELOPMENT

As indicated in Chapter V, additional reservoirs will be needed if the ultimate developed potential of the New River Basin in Virginia is to be realized. It is felt that 50 percent regulation of the flow at Radford, Virginia, represents a high degree of regulation, and at the present time is a reasonable goal. This regulation would assure, based upon the period of record, that minimum 1-day flow would not fall below 1,872 CFS at Radford. This goal is 1,272 CFS above the minimum 1-day 30-year existing flow and would mean effectively an approximate threefold increase in the flow now occurring.

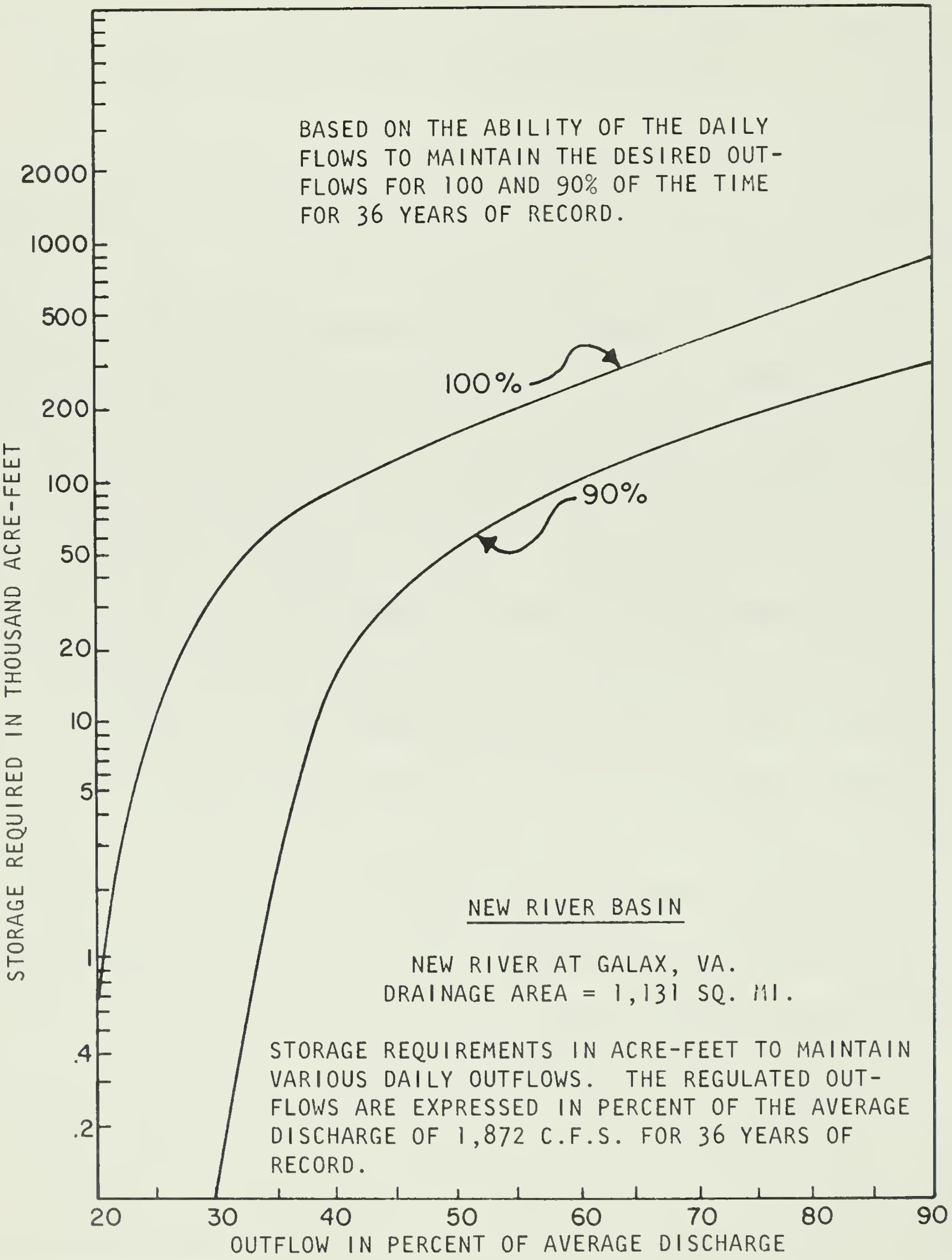
A series of possible reservoirs has been analyzed to ascertain what would be needed in additional capacity if the 50 percent regulation goal is to be achieved. A restriction in drawdown has been placed on the reservoirs in order that any potential project would be truly multipurpose. A maximum drawdown of 10 feet has been assumed. It is realized that this figure is not an unchallengeable value. In certain areas it may be shown that 10 feet of drawdown is detrimental and in other instances, an excess of 10 feet may be acceptable. It does represent, however, a reasonable figure for planning purposes.

The discharge records for stations Galax, Radford, and Glen Lyn have been used to determine flows which could be assured by various amounts of stored water. The analysis is based upon the period of record at each station. The flows were determined on the basis of average daily flows at each of the stations. Plates 40, 41, and 42 show the results of the determinations.

As an example of the use of the curves, assume that an outflow of 749 CFS is desired at the Galax station 100 percent of the time based upon the period of record. At the Galax station 749 CFS is 40 percent of the average daily discharge, and the corresponding storage to meet the 40 percent regulation requirement is approximately 100,000 acre-feet.

Table 5 shows the regulation possible under the assumption the Blue Ridge Project is operated in accordance with the Virginia Division of Water Resources' management plan. It is also assumed that three projects in Virginia and an additional project in North Carolina will be constructed. Two levels of return frequency were assumed, namely, 90 percent of the time and 100 percent of the time. An inspection of the Table shows that the 1,872 CFS objective with all projects in operation can be met approximately 90 percent of the time and 1,750 CFS of the ultimate objective can be met 100 percent of the time.

Figures shown under each project heading are flows which could be attained with all projects up to and including the reservoir heading under which the figure is read.



BASED ON THE ABILITY OF THE DAILY FLOWS TO MAINTAIN THE DESIRED OUTFLOWS FOR 100 AND 90% OF THE TIME FOR 36 YEARS OF RECORD.

NEW RIVER BASIN

NEW RIVER AT GALAX, VA.
DRAINAGE AREA = 1,131 SQ. MI.

STORAGE REQUIREMENTS IN ACRE-FEET TO MAINTAIN VARIOUS DAILY OUTFLOWS. THE REGULATED OUTFLOWS ARE EXPRESSED IN PERCENT OF THE AVERAGE DISCHARGE OF 1,872 C.F.S. FOR 36 YEARS OF RECORD.

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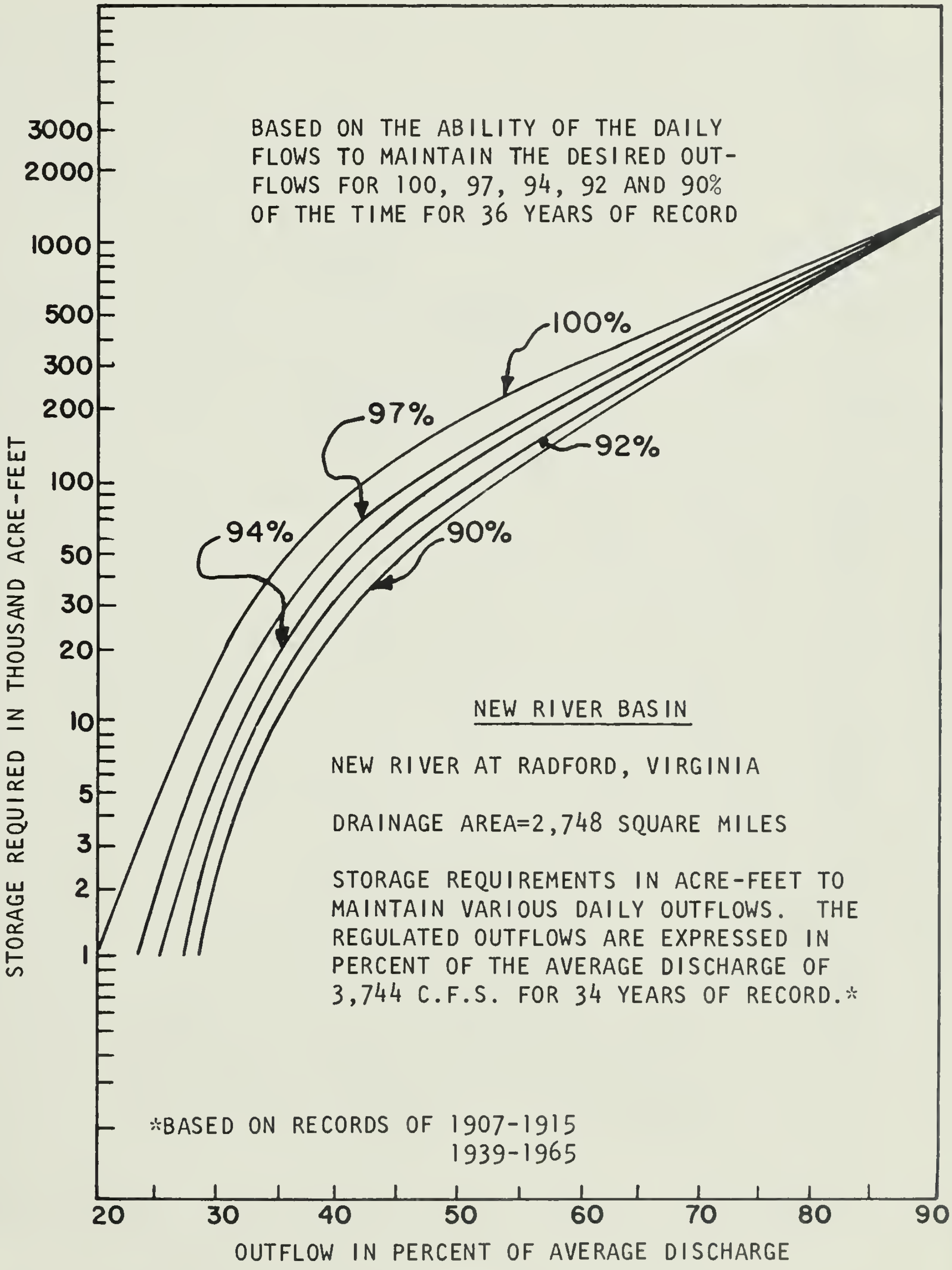
PLATE NO. 40



BASED ON THE ABILITY OF THE DAILY FLOWS TO MAINTAIN THE DESIRED OUTFLOWS FOR 100, 97, 94, 92 AND 90% OF THE TIME FOR 36 YEARS OF RECORD

NEW RIVER BASIN

NEW RIVER AT RADFORD, VIRGINIA

DRAINAGE AREA=2,748 SQUARE MILES

STORAGE REQUIREMENTS IN ACRE-FEET TO MAINTAIN VARIOUS DAILY OUTFLOWS. THE REGULATED OUTFLOWS ARE EXPRESSED IN PERCENT OF THE AVERAGE DISCHARGE OF 3,744 C.F.S. FOR 34 YEARS OF RECORD.*

*BASED ON RECORDS OF 1907-1915
1939-1965

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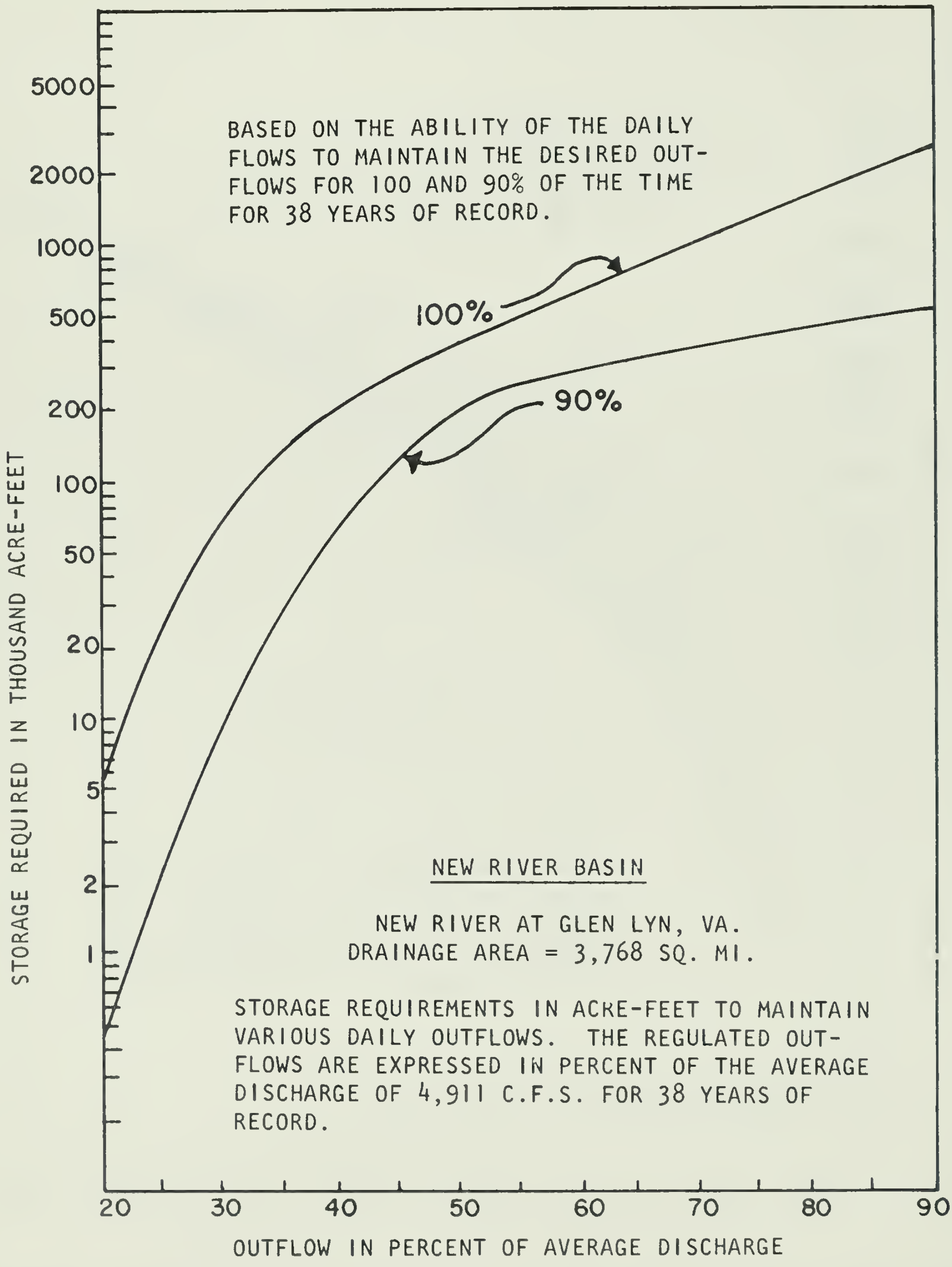

BASED ON THE ABILITY OF THE DAILY FLOWS TO MAINTAIN THE DESIRED OUTFLOWS FOR 100 AND 90% OF THE TIME FOR 38 YEARS OF RECORD.

NEW RIVER BASIN

NEW RIVER AT GLEN LYN, VA.
DRAINAGE AREA = 3,768 SQ. MI.

STORAGE REQUIREMENTS IN ACRE-FEET TO MAINTAIN VARIOUS DAILY OUTFLOWS. THE REGULATED OUTFLOWS ARE EXPRESSED IN PERCENT OF THE AVERAGE DISCHARGE OF 4,911 C.F.S. FOR 38 YEARS OF RECORD.

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TABLE 5

NEW RIVER BASIN

POSSIBLE FUTURE FLOW REGULATION SCHEME - LOW FLOWS

LOW FLOWS IN C.F.S.

NEW RIVER STATION OR LOCATION	TRIBUTARIES STATION OR LOCATION	EXISTING		WITH BLUE RIDGE PROJECT 50,000 A.F. W.Q. 130,000 A.F. POWER REGULATED		WITH PROJECT IN NORTH CAROLINA 50,000 A.F. W.Q. REGULATED		WITH LITTLE RIVER PROJECT 27,500 A.F. REGULATED		WITH REED CREEK PROJECT 18,000 A.F. REGULATED		WITH BIG REED ISLAND PROJECT 40,000 A.F. REGULATED	
		1- DAY	7- DAY	1- DAY	7-DAY	1- DAY	7- DAY	1- DAY	7- DAY	1- DAY	7- DAY	1- DAY	7- DAY
						90% OF THE TIME							
Galax		250	340	250	600	600	1,240						
	Little River	51	72					51	230				
	Reed Creek	25	46							25	140		
	Big Reed Island	78	97									78	300
Radford		620	950	1,200	1,500	1,400	1,800	1,766	2,000	1,866	2,100	2,090	2,325
Glen Lyn		740	1,180	1,400	1,800	1,730	2,030	1,890	2,200	1,990	2,300	2,215	2,510
						100% OF THE TIME							
Galax		250	340	250	1,000	600	1,100						
	Little River	51	72					51	230				
	Reed Creek	25	46							25	140		
	Big Reed Island	78	97									78	300
Radford		620	950	1,200	1,535	1,400	1,658	1,600	1,715	1,650	1,760	1,750	1,834
Glen Lyn		740	1,180	1,400	1,890	1,730	2,040	1,890	2,121	1,990	2,185	2,215	2,288